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PHYSICAL TABLES

PREPARED BY

THOMAS GRAY

FOURTH REVISED EDITION

CITY OF WASHINGTON
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1908

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ADVERTISEMENT TO REVISED EDITION.

The edition of the Smithsonian Physical Tables issued in 1896 having become exhausted, a careful reëxamination of the original work has been made at my request by the author, Professor Gray, and the few changes found necessary have been made in the plates.

S. P. Langley,
Secretary.

Smithsonian Institution,
Washington City, *October 30, 1897.*

ADVERTISEMENT TO SECOND REVISED EDITION.

The revised edition of the Smithsonian Physical Tables issued in 1897 having become exhausted, and the demand continuing, a second revised edition is now issued. The author, Professor Gray, has again examined the work and made a few corrections in the plates, table 283 in particular being rewritten to agree with the recent report of the International Committee on Atomic Weights.

S. P. Langley,
Secretary.

Smithsonian Institution,
Washington City, *January, 1903.*

ADVERTISEMENT TO THIRD REVISED EDITION.

The second revised edition of the Smithsonian Physical Tables issued in January, 1903, having become exhausted, and the demand for the work continuing, a third revised edition is now published, in which the author has made a few corrections to agree with the latest researches.

S. P. Langley,
Secretary.

Smithsonian Institution,
Washington City *April, 1904.*

ADVERTISEMENT TO FOURTH REVISED EDITION.

The third revised edition of the Smithsonian Physical Tables issued in 1901 having become exhausted, a fourth revised edition is now published, in which the author, Professor Gray, has made a few corrections, particularly in the tables of equivalents of metric and British Imperial weights and measures, which are here brought up to date. The other changes from the third edition are in Table 36, page 27, 2.3349×10^{-2} for 2.3349; Table 100, page 89, coal gas, 0.320 for 0.340, 0.740 for 0.450, 0.000414 for 0.000421, 0.000957 for 0.000558, 0.02583 for 0.02628, and 0.05973 for 0.03483; Table 102, page 92, Temperature 20°, 2126 for 4126; Table 104, page 94, Temperature 46° to 95°, 1.01014, etc., for 1.00014, etc., and 100°, 1.02312 for 1.00312; foot-note to Table 133, page 120, t', and $a(t'-t)$ the correction for temperature, for t' and at the correction for temperature; Table 174, page 162, .0118421 for .0184210; Table 175, page 162, .16058 for .16858; Table 227, page 220, 414×10^5 ergs per gramme degree for 414.0 ergs per gramme degree; Table 268, page 258, Less than $\frac{1}{100}$ for Less than $\frac{1}{1000}$.

CHAS. D. WALCOTT,
Secretary.

SMITHSONIAN INSTITUTION,
WASHINGTON CITY, *June, 1908.*

ADVERTISEMENT.

In connection with the system of meteorological observations established by the Smithsonian Institution about 1850, a series of meteorological tables was compiled by Dr. Arnold Guyot, at the request of Secretary Henry, and was published in 1852. A second edition was issued in 1857, and a third edition, with further amendments, in 1859. Though primarily designed for meteorological observers reporting to the Smithsonian Institution, the tables were so widely used by physicists that, after twenty-five years of valuable service, the work was again revised and a fourth edition was published in 1884. In a few years the demand for the tables exhausted the edition, and it appeared to me desirable to recast the work entirely, rather than to undertake its revision again. After careful consideration I decided to publish a new work in three parts — Meteorological Tables, Geographical Tables, and Physical Tables — each representative of the latest knowledge in its field, and independent of the others, but the three forming a homogeneous series. Although thus historically related to Dr. Guyot's Tables, the present work is so entirely changed with respect to material, arrangement, and presentation that it is not a fifth edition of the older tables, but essentially a new publication.

The first volume of the new series of Smithsonian Tables (the Meteorological Tables) appeared in 1893, and so great has been the demand for it that a second edition has already become necessary. The second volume of the series (the Geographical Tables), prepared by Prof. R. S. Woodward, was published in 1894. The present volume (the Physical Tables), forming the third of the series, has been prepared by Prof. Thomas Gray, of the Rose Polytechnic Institute, Terre Haute, Indiana, who has given to the work the results of a wide experience.

S. P. Langley, *Secretary*.

PREFACE.

In the space assigned to this book it was impossible to include, even approximately, all the physical data available. The object has been to make the tables easy of reference and to contain the data most frequently required. In the subjects included it has been necessary in many cases to make brief selections from a large number of more or less discordant results obtained by different experimenters. I have endeavored, as far as possible, to compile the tables from papers which are vouched for by well-known authorities, or which, from the method of experiment and the apparent care taken in the investigation, seem likely to give reliable results.

Such matter as is commonly found in books of mathematical tables has not been included, as it seemed better to utilize the space for physical data. Some tables of a mathematical character which are useful to the physicist, and which are less easily found, have been given. Many of these have been calculated for this book, and where they have not been so calculated their source is given.

The authorities from which the physical data have been derived are quoted on the same page with the table, and this is the case also with regard to explanations of the meaning or use of the tabular numbers. In many cases the actual numbers given in the tables are not to be found in the memoirs quoted. In such cases the tabular numbers have been obtained by interpolation or calculation from the published results. The reason for this is the desirability of uniform change of argument in the tables, in order to save space and to facilitate comparison of results. Where it seemed desirable the tables contain values both in metric and in British units, but as a rule the centimetre, gramme, and second have been used as fundamental units. In the comparison of British and metric units, and quantities expressed in them, the metre has been taken as equal to 39.37 inches, which is the legal ratio in the United States. It is hardly possible that a series

of tables, such as those here given, involving so much transcribing, interpolation, and calculation, can be free from errors, but it is hoped that these are not so numerous as to seriously detract from the use of the book.

I wish to acknowledge much active assistance and many valuable suggestions during the preparation of the book from Professors S. P. Langley, Carl Barus, F. W. Clarke, C. L. Mees, W. A. Noyes, and Mr. R. E. Huthsteiner. I am also under obligations to Professors Landolt and Börnstein, who kindly placed an early copy of their "Physikalisch-Chemische Tabellen" at my disposal.

THOMAS GRAY.

ROSE POLYTECHNIC INSTITUTE,
TERRE HAUTE, IND., July 13, 1896.

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INTRODUCTION.

UNITS OF MEASUREMENT AND CONVERSION FORMULÆ.

Units. — The quantitative measure of anything is a number which expresses the ratio of the magnitude of the thing to the magnitude of some other thing of the same kind. In order that the number expressing the measure may be intelligible, the magnitude of the thing used for comparison must be known. This leads to the conventional choice of certain magnitudes as units of measurement, and any other magnitude is then simply expressed by a number which tells how many magnitudes equal to the unit of the same kind of magnitude it contains. For example, the distance between two places may be stated as a certain number of miles or of yards or of feet. In the first case, the mile is assumed as a known distance; in the second, the yard, and in the third, the foot. What is sought for in the statement is to convey an idea of the distance by describing it in terms of distances which are either familiar or easily referred to for comparison. Similarly quantities of matter are referred to as so many tons or pounds or grains and so forth, and intervals of time as a number of hours or minutes or seconds. Generally in ordinary affairs such statements appeal to experience; but, whether this be so or not, the statement must involve some magnitude as a fundamental quantity, and this must be of such a character that, if it is not known, it can be readily referred to. We become familiar with the length of a mile by walking over distances expressed in miles, with the length of a yard or a foot by examining a yard or a foot measure and comparing it with something easily referred to, — say our own height, the length of our foot or step, — and similarly for quantities of other kinds. This leads us to be able to form a mental picture of such magnitudes when the numbers expressing them are stated, and hence to follow intelligently descriptions of the results of scientific work. The possession of copies of the units enables us by proper comparisons to find the magnitude-numbers expressing physical quantities for ourselves. The numbers descriptive of any quantity must depend on the intrinsic magnitude of the unit in terms of which it is described. Thus a mile is 1760 yards, or 5280 feet, and hence when a mile is taken as the unit the magnitude-number for the distance is 1, when a yard is taken as the unit the magnitude-number is 1760, and when a foot is taken it is 5280. Thus, to obtain the magnitude-number for a quantity in terms of a new unit when it is already known in terms of another we have to multiply the old magnitude-number by the ratio of the intrinsic values of the old and new units; that is, by the number of the new units required to make one of the old.

Fundamental Units of Length and Mass. — It is desirable that as few different kinds of unit quantities as possible should be introduced into our measurements, and since it has been found possible and convenient to express a large number of physical quantities in terms of length or mass or time units and combinations of these they have been very generally adopted as fundamental units. Two systems of such units are used in this country for scientific measurements, namely, the British and the French, or metric, systems. Tables of conversion factors are given in the book for facilitating comparisons between quantities expressed in terms of one system with similar quantities expressed in the other. In the British system the standard unit of length is the yard, and it is defined as follows: "The straight line or distance between the transverse lines in the two gold plugs in the bronze bar deposited in the Office of the Exchequer shall be the genuine Standard of Length at 62° F., and if lost it shall be replaced by means of its copies." [The authorized copies here referred to are preserved at the Royal Mint, the Royal Society of London, the Royal Observatory at Greenwich, and the New Palace at Westminster.]

The British standard unit of mass is the pound avoirdupois, and is the mass of a piece of platinum marked "P. S. 1844, 1 lb.," which is preserved in the Exchequer Office. Authorized copies of this standard are kept at the same places as those of the standard of length.

In the metric system the standard of length is defined as the distance between the ends of a certain platinum bar (the *mètre des Archives*) when the whole bar is at the temperature 0° Centigrade. The bar was made by Borda, and is preserved in the national archives of France. A line-standard metre has been constructed by the International Bureau of Weights and Measures, and is known as the International Prototype Metre. This standard is of the same length as the Borda standard. A number of standard-metre bars which have been carefully compared with the International Prototype have lately been made by the International Bureau of Weights and Measures and furnished to the various governments who have contributed to the support of that bureau. These copies are called National Prototypes.

Borda, Delambre, Laplace, and others, acting as a committee of the French Academy, recommended that the standard unit of length should be the ten millionth part of the length, from the equator to the pole, of the meridian passing through Paris. In 1795 the French Republic passed a decree making this the legal standard of length, and an arc of the meridian extending from Dunkirk to Barcelona was measured by Delambre and Mechain for the purpose of realizing the standard. From the results of that measurement the metre bar was made by Borda. The metre is not now defined as stated above, but as the length of Borda's rod, and hence subsequent measurements of the length of the meridian have not affected the length of the metre.

The French, or metric, standard of mass, the kilogramme, is the mass of a piece of platinum also made by Borda in accordance with the same decree of the Republic. It was connected with the standard of length by being made as nearly as possible of the same mass as that of a cubic decimetre of distilled water at the temperature of 4° C., or nearly the temperature of maximum density.

As in the case of the metre, the International Bureau of Weights and Measures

has made copies of the kilogramme. One of these is taken as standard, and is called the International Prototype Kilogramme. The others were distributed in the same manner as the metre standards, and are called National Prototypes.

Comparisons of the French and British standards are given in tabular form in Table 2; and similarly Table 3, differing slightly from the British, gives the legal ratios in the United States. In the metric system the decimal subdivision is used, and thus we have the decimetre, the centimetre, and the millimetre as subdivisions, and the dekametre, hektometre, and kilometre as multiples. The centimetre is most commonly used in scientific work.

Time. — The unit of time in both the systems here referred to is the mean solar second, or the 86,400th part of the mean solar day. The unit of time is thus founded on the average time required for the earth to make one revolution on its axis relatively to the sun as a fixed point of reference.

Derived Units. — Units of quantities depending on powers greater than unity of the fundamental length, mass, and time units, or on combinations of different powers of these units, are called "derived units." Thus, the unit of area and of volume are respectively the area of a square whose side is the unit of length and the volume of a cube whose edge is the unit of length. Suppose that the area of a surface is expressed in terms of the foot as fundamental unit, and we wish to find the area-number when the yard is taken as fundamental unit. The yard is 3 times as long as the foot, and therefore the area of a square whose side is a yard is 3×3 times as great as that whose side is a foot. Thus, the surface will only make one ninth as many units of area when the yard is the unit of length as it will make when the foot is that unit. To transform, then, from the foot as old unit to the yard as new unit, we have to multiply the old area-number by $1/9$, or by the ratio of the magnitude of the old to that of the new unit of area. This is the same rule as that given above, but it is usually more convenient to express the transformations in terms of the fundamental units directly. In the above case, since on the method of measurement here adopted an area-number is the product of a length-number by a length-number the ratio of two units is the square of the ratio of the intrinsic values of the two units of length. Hence, if l be the ratio of the magnitude of the old to that of the new unit of length, the ratio of the corresponding units of area is l^2. Similarly the ratio of two units of volume will be l^3, and so on for other quantities.

Dimensional Formulæ. — It is convenient to adopt symbols for the ratios of length units, mass units, and time units, and adhere to their use throughout; and in what follows, the small letters, l, m, t, will be used for these ratios. These letters will always represent simple numbers, but the magnitude of the number will depend on the relative magnitudes of the units the ratios of which they represent. When the values of the numbers represented by l, m, t are known, and the powers of l, m, and t involved in any particular unit are also known, the factor for transformation is at once obtained. Thus, in the above example, the value of l was $1/3$ and the power of l involved in the expression for area is l^2; hence, the factor for transforming from square feet to square yards is $1/9$. These factors

have been called by Prof. James Thomson "change ratios," which seems an appropriate term. The term "conversion factor" is perhaps more generally known, and has been used throughout this book.

Convèrsion Factor. — In order to determine the symbolic expression for the conversion factor for any physical quantity, it is sufficient to determine the degree to which the quantities length, mass, and time are involved in the quantity. Thus, a velocity is expressed by the ratio of the number representing a length to that representing an interval of time, or L/T, an acceleration by a velocity-number divided by an interval of time-number, or L/T^2, and so on, and the corresponding ratios of units must therefore enter to precisely the same degree. The factors would thus be for the above cases, l/t and l/t^2. Equations of the form above given for velocity and acceleration which show the dimensions of the quantity in terms of the fundamental units are called "dimensional equations." Thus

$$E = ML^2T^{-2}$$

is the dimensional equation for energy, and ML^2T^{-2} is the dimensional formula for energy.

In general, if we have an equation for a physical quantity

$$Q = CL^aM^bT^c,$$

where C is a constant and LMT represents length, mass, and time in terms of one set of units, and we wish to transform to another set of units in terms of which the length, mass, and time are $L_lM_lT_l$, we have to find the value of $\frac{L_l}{L}, \frac{M_l}{M}, \frac{T_l}{T}$, which in accordance with the convention adopted above will be $l_l m_l t_l$, or the ratios of the magnitudes of the old to those of the new units.

Thus $L_l = Ll$, $M_l = Mm$, $T_l = Tt$, and if Q_l be the new quantity-number

$$\begin{aligned} Q_l &= CL_l^aM_l^bT_l^c \\ &= CL^al^aM^bm^bT^ct^c = Ql^am^bt^c, \end{aligned}$$

or the conversion factor is $l^am^bt^c$, a quantity of precisely the same form as the dimension formula $L^aM^bT^c$.

We now proceed to form the dimensional and conversion factor formulæ for the more commonly occurring derived units.

1. **Area.** — The unit of area is the square the side of which is measured by the unit of length. The area of a surface is therefore expressed as

$$S = CL^2,$$

where C is a constant depending on the shape of the boundary of the surface and L a linear dimension. For example, if the surface be square and L be the length of a side C is unity. If the boundary be a circle and L be a diameter $C = \pi/4$, and so on. The dimensional formula is thus L^2, and the conversion factor l^2.

2. **Volume.** — The unit of volume is the volume of a cube the edge of which is measured by the unit of length. The volume of a body is therefore expressed as

$$V = CL^3,$$

where as before C is a constant depending on the shape of the boundary. The dimensional formula is L^3 and the conversion factor l^3.

3. **Density.** — The density of a substance is the quantity of matter in the unit of volume. The dimension formula is therefore M/V or ML^{-3}, and conversion factor ml^{-3}.

Example. — The density of a body is 150 in pounds per cubic foot: required the density in grains per cubic inch.

Here m is the number of grains in a pound = 7000, and l is the number of inches in a foot = 12; $\therefore ml^{-3} = 7000/12^3 = 4.051$. Hence the density is $150 \times 4.051 = 607.6$ in grains per cubic inch.

NOTE. — The specific gravity of a body is the ratio of its density to the density of a standard substance. The dimension formula and conversion factor are therefore both unity.

4. **Velocity.** — The velocity of a body at any instant is given by the equation $v = \frac{dL}{dT}$, or velocity is the ratio of a length-number to a time-number. The dimension formula is LT^{-1}, and the conversion factor lt^{-1}.

Example. — A train has a velocity of 60 miles an hour: what is its velocity in feet per second?

Here $l = 5280$ and $t = 3600$; $\therefore lt^{-1} = \frac{5280}{3600} = \frac{44}{30} = 1.467$. Hence the velocity $= 60 \times 1.467 = 88.0$ in feet per second.

5. **Angle.** — An angle is measured by the ratio of the length of an arc to the length of the radius of the arc. The dimension formula and the conversion factor are therefore both unity.

6. **Angular Velocity.** — Angular velocity is the ratio of the magnitude of the angle described in an interval of time to the length of the interval. The dimension formula is therefore T^{-1}, and the conversion factor is t^{-1}.

7. **Linear Acceleration.** — Acceleration is the rate of change of velocity or $a = \frac{dv}{dt}$. The dimension formula is therefore VT^{-1} or LT^{-2}, and the conversion factor is lt^{-2}.

Example. — A body acquires velocity at a uniform rate, and at the end of one minute is moving at the rate of 20 kilometres per hour: what is the acceleration in centimetres per second per second?

Since the velocity gained was 20 kilometres per hour in one minute, the acceleration was 1200 kilometres per hour per hour.

Here $l = 100\,000$ and $t = 3600$; $\therefore lt^{-2} = 100\,000/3600^2 = .00771$, and therefore acceleration $= .00771 \times 1200 = 9.26$ centimetres per second.

8. **Angular Acceleration.** — Angular acceleration is rate of change of angu-

lar velocity. The dimensional formula is thus $\frac{\text{angular velocity}}{\text{T}}$ or T^{-2}, and the conversion factor t^{-2}.

9. **Solid Angle.** — A solid angle is measured by the ratio of the surface of the portion of a sphere enclosed by the conical surface forming the angle to the square of radius of the spherical surface, the centre of the sphere being at the vertex of the cone. The dimensional formula is therefore $\frac{\text{area}}{\text{L}^2}$ or 1, and hence the conversion factor is also 1.

10. **Curvature.** — Curvature is measured by the rate of change of direction of the curve with reference to distance measured along the curve as independent variable. The dimension formula is therefore $\frac{\text{angle}}{\text{length}}$ or L^{-1}, and the conversion factor is l^{-1}.

11. **Tortuosity.** — Tortuosity is measured by the rate of rotation of the tangent plane round the tangent to the curve of reference when length along the curve is independent variable. The dimension formula is therefore $\frac{\text{angle}}{\text{length}}$ or L^{-1}, and the conversion factor is l^{-1}.

12. **Specific Curvature of a Surface.** — This was defined by Gauss to be, at any point of the surface, the ratio of the solid angle enclosed by a surface formed by moving a normal to the surface round the periphery of a small area containing the point, to the magnitude of the area. The dimensional formula is therefore $\frac{\text{solid angle}}{\text{surface}}$ or L^{-2}, and the conversion factor is thus l^{-2}.

13. **Momentum.** — This is quantity of motion in the Newtonian sense, and is, at any instant, measured by the product of the mass-number and the velocity-number for the body.

Thus the dimension formula is MV or MLT^{-1}, and the conversion factor mlt^{-1}.

Example. — A mass of 10 pounds is moving with a velocity of 30 feet per second: what is its momentum when the centimetre, the gramme, and the second are fundamental units?

Here $m = 453.59$, $l = 30.48$, and $t = 1$; $\therefore mlt^{-1} = 453.59 \times 30.48 = 13825$. The momentum is thus $13825 \times 10 \times 30 = 4\,147\,500$.

14. **Moment of Momentum.** — The moment of momentum of a body with reference to a point is the product of its momentum-number and the number expressing the distance of its line of motion from the point. The dimensional formula is thus ML^2T^{-1}, and hence the conversion factor is ml^2t^{-1}.

15. **Moment of Inertia.** — The moment of inertia of a body round any axis is expressed by the formula Σmr^2, where m is the mass of any particle of the body

and r its distance from the axis. The dimension formula for the sum is clearly the same as for each element, and hence is ML^2. The conversion factor is therefore ml^2.

16. **Angular Momentum.** — The angular momentum of a body round any axis is the product of the numbers expressing the moment of inertia and the angular velocity of the body. The dimensional formula and the conversion factor are therefore the same as for moment of momentum given above.

17. **Force.** — A force is measured by the rate of change of momentum it is capable of producing. The dimension formulæ for force and "time rate of change of momentum" are therefore the same, and are expressed by the ratio of momentum-number to time-number or MLT^{-2}. The conversion factor is thus mlt^{-2}.

NOTE. — When mass is expressed in pounds, length in feet, and time in seconds, the unit force is called the poundal. When grammes, centimetres, and seconds are the corresponding units the unit of force is called the dyne.

Example. Find the number of dynes in 25 poundals.

Here $m = 453.59$, $l = 30.48$, and $t = 1$; $\therefore mlt^{-2} = 453.59 \times 30.48 = 13825$ nearly. The number of dynes is thus $13825 \times 25 = 345625$ approximately.

18. **Moment of a Couple, Torque, or Twisting Motive.** — These are different names for a quantity which can be expressed as the product of two numbers representing a force and a length. The dimension formula is therefore FL or ML^2T^{-2}, and the conversion factor is ml^2t^{-2}.

19. **Intensity of a Stress.** — The intensity of a stress is the ratio of the number expressing the total stress to the number expressing the area over which the stress is distributed. The dimensional formula is thus FL^{-2} or $ML^{-1}T^{-2}$, and the conversion factor is $ml^{-1}t^{-2}$.

20. **Intensity of Attraction, or "Force at a Point."** — This is the force of attraction per unit mass on a body placed at the point, and the dimensional formula is therefore FM^{-1} or LT^{-2}, the same as acceleration. The conversion factors for acceleration therefore apply.

21. **Absolute Force of a Centre of Attraction, or "Strength of a Centre."** — This is the intensity of force at unit distance from the centre, and is therefore the force per unit mass at any point multiplied by the square of the distance from the centre. The dimensional formula thus becomes FL^2M^{-1} or L^3T^{-2}. The conversion factor is therefore l^3t^{-2}.

22. **Modulus of Elasticity.** — A modulus of elasticity is the ratio of stress intensity to percentage strain. The dimension of percentage strain is a length divided by a length, and is therefore unity. Hence, the dimensional formula of a modulus of elasticity is the same as that of stress intensity, or $ML^{-1}T^{-2}$, and the conversion factor is thus also $ml^{-1}t^{-2}$.

23. **Work and Energy.** — When the point of application of a force, acting on a body, moves in the direction of the force, work is done by the force, and the amount is measured by the product of the force and displacement numbers. The dimensional formula is therefore FL or ML^2T^{-2}.

The work done by the force either produces a change in the velocity of the body or a change of shape or configuration of the body, or both. In the first case it produces a change of kinetic energy, in the second a change of potential energy. The dimension formulæ of energy and work, representing quantities of the same kind, are identical, and the conversion factor for both is ml^2t^{-2}.

24. **Resilience.** — This is the work done per unit volume of a body in distorting it to the elastic limit or in producing rupture. The dimension formula is therefore $ML^2T^{-2}L^{-3}$ or $ML^{-1}T^{-2}$, and the conversion factor $ml^{-1}t^{-2}$.

25. **Power, or Activity.** — Power — or, as it is now very commonly called, activity — is defined as the time rate of doing work, or if W represent work and P power $P = \frac{dw}{dt}$. The dimensional formula is therefore WT^{-1} or ML^2T^{-3}, and the conversion factor ml^2t^{-3}, or for problems in gravitation units more conveniently flt^{-1}, where f stands for the force factor.

Examples. (*a*) Find the number of gramme centimetres in one foot pound.

Here the units of force are the attraction of the earth on the pound* and the gramme of matter, and the conversion factor is fl, where f is 453.59 and l is 30.48.

Hence the number is $453.59 \times 30.48 = 13825$.

(*b*) Find the number of foot poundals in 1 000 000 centimetre dynes.

Here $m = 1/453.59$, $l = 1/30.48$, and $t = 1$; $\therefore\ ml^2t^{-2} = 1/453.59 \times 30.48^2$, and $10^6ml^2t^{-2} = 10^6/453.59 \times 30.48^2 = 2.373$.

(*c*) If gravity produces an acceleration of 32.2 feet per second per second, how many watts are required to make one horse-power?

One horse-power is 550 foot pounds per second, or $550 \times 32.2 = 17710$ foot poundals per second. One watt is 10^7 ergs per second, that is, 10^7 dyne centimetres per second. The conversion factor is ml^2t^{-3}, where $m = 453.59$, $l = 30.48$, and $t = 1$, and the result has to be divided by 10^7, the number of dyne centimetres per second in the watt.

Hence, $17710\, ml^2t^{-3}/10^7 = 17710 \times 453.59 \times 30.48^2/10^7 = 746.3$.

(*d*) How many gramme centimetres per second correspond to 33000 foot pounds per minute?

The conversion factor suitable for this case is flt^{-1}, where f is 453.59, l is 30.48, and t is 60.

Hence, $33000\, flt^{-1} = 33000 \times 453.59 \times 30.48/60 = 7\,604\,000$ nearly.

* It is important to remember that in problems like that here given the term "pound" or "gramme" refers to force and not to mass.

HEAT UNITS.

1. If heat be measured in dynamical units its dimensions are the same as those of energy, namely ML^2T^{-2}. The most common measurements, however, are made in thermal units, that is, in terms of the amount of heat required to raise the temperature of unit mass of water one degree of temperature at some stated temperature. This method of measurement involves the unit of mass and some unit of temperature, and hence if we denote temperature-numbers by Θ and their conversion factors by θ the dimensional formula and conversion factor for quantity of heat will be $M\Theta$ and $m\theta$ respectively. The relative amount of heat compared with water as standard substance required to raise unit mass of different substances one degree in temperature is called their specific heat, and is a simple number.

Unit volume is sometimes used instead of unit mass in the measurement of heat, the units being then called thermometric units. The dimensional formula is in that case changed by the substitution of volume for mass, and becomes $L^3\Theta$, and hence the conversion factor is to be calculated from the formula $l^3\theta$.

For other physical quantities involving heat we have: —

2. **Coefficient of Expansion.** — The coefficient of expansion of a substance is equal to the ratio of the change of length per unit length (linear), or change of volume per unit volume (voluminal) to the change of temperature. These ratios are simple numbers, and the change of temperature is inversely as the magnitude of the unit of temperature. Hence the dimensional and conversion-factor formulæ are Θ^{-1} and θ^{-1}.

3. **Conductivity, or Specific Conductance.** — This is the quantity of heat transmitted per unit of time per unit of surface per unit of temperature gradient. The equation for conductivity is therefore, with H as quantity of heat,

$$K = \frac{H}{\frac{\Theta}{L} L^2 T}$$

and the dimensional formula $\frac{H}{\Theta LT} = \frac{M}{LT}$, which gives $ml^{-1}t^{-1}$ for conversion factor.

In thermometric units the formula becomes L^2T^{-1}, which properly represents diffusivity. In dynamical units H becomes ML^2T^{-2}, and the formula changes to $MLT^{-3}\Theta^{-1}$. The conversion factors obtained from these are l^2t^{-1} and $mlt^{-3}\theta^{-1}$ respectively.

Similarly for emission and absorption we have —

4. **Emissivity and Immissivity.** — These are the quantities of heat given off by or taken in by the body per unit of time per unit of surface per unit difference of temperature between the surface and the surrounding medium. We thus get the equation

$$EL^2\Theta T = H = M\Theta.$$

The dimensional formula for E is therefore $ML^{-2}T^{-1}$, and the conversion factor

$ml^{-2}t^{-1}$. In thermometric units by substituting l^2 for m the factor becomes lt^{-1}, and in dynamical units $mt^{-3}\theta^{-1}$.

5. **Thermal Capacity.** — This is the product of the number for mass and the specific heat, and hence the dimensional formula and conversion factor are simply M and m.

6. **Latent Heat.** — Latent heat is the ratio of the number representing the quantity of heat required to change the state of a body to the number representing the quantity of matter in the body. The dimensional formula is therefore $M\Theta/M$ or Θ, and hence the conversion factor is simply the ratio of the temperature units or θ. In dynamical units the factor is l^2t^{-2}.*

7. **Joule's Equivalent.** — Joule's dynamical equivalent is connected with quantity of heat by the equation

$$ML^2T^{-2} = JH \text{ or } JM\Theta.$$

This gives for the dimensional formula of J the expression $L^2T^{-2}\Theta^{-1}$. The conversion factor is thus represented by $l^2t^{-2}\theta^{-1}$. When heat is measured in dynamical units J is a simple number.

8. **Entropy.** — The entropy of a body is directly proportional to the quantity of heat it contains and inversely proportional to its temperature. The dimensional formula is thus $M\Theta/\Theta$ or M, and the conversion factor is m. When heat is measured in dynamical units the factor is $ml^2t^{-2}\theta^{-1}$.

Examples. (*a*) Find the relation between the British thermal unit, the calorie, and the therm.

Neglecting the variation of the specific heat of water with temperature, or defining all the units for the same temperature of the standard substance, we have the following definitions. The *British thermal unit* is the quantity of heat required to raise the temperature of one pound of water 1° F. The *calorie* is the quantity of heat required to raise the temperature of one kilogramme of water 1° C. The *therm* is the quantity of heat required to raise the temperature of one gramme of water 1° C. Hence: —

(1) To find the number of calories in one British thermal unit, we have $m = .45399$ and $\theta = \frac{5}{9}$; $\therefore m\theta = .45399 \times 5/9 = .25199$.

(2) To find the number of therms in one calorie, $m = 1000$ and $\theta = 1$; $\therefore m\theta = 1000$.

It follows at once that the number of therms in one British thermal unit is $1000 \times .25199 = 251.99$.

(*b*) What is the relation between the foot grain second Fahrenheit-degree and the centimetre gramme second Centigrade-degree units of conductivity?

The number of the latter units in one of the former is given by the for-

* It will be noticed that when Θ is given the dimension formula L^2T^{-2} the formulæ in thermal and dynamical units are always identical. The thermometric units practically suppress mass.

mula $ml^{-1}t^{-1}\theta^0$, where $m = .064799$, $l = 30.48$, and $t = 1$, and is therefore $=$ $.064799/30.48 = 2.126 \times 10^{-3}$.

(*c*) Find the relation between the units stated in (*b*) for emissivity.

In this case the conversion formula is $ml^{-2}t^{-1}$, where ml and t have the same value as before. Hence the number of the latter units in the former is $0.064799/30.48^2 = 6.975 \times 10^{-5}$.

(*d*) Find the number of centimetre gramme second units in the inch grain hour unit of emissivity.

Here the formula is $ml^{-2}t^{-1}$, where $m = 0.064799$, $l = 2.54$, and $t = 3600$. Therefore the required number is $0.064799/2.54^2 \times 3600 = 2.790 \times 10^{-6}$.

(*e*) If Joule's equivalent be 776 foot pounds per pound of water per degree Fahrenheit, what will be its value in gravitation units when the metre, the kilogramme, and the degree Centigrade are units?

The conversion factor in this case is $\frac{l^2t^{-2}\theta^{-1}}{lt^{-2}}$ or $l\theta^{-1}$, where $l = .3048$ and $\theta^{-1} = 1.8$; $\therefore$ $776 \times .3048 \times 1.8 = 425.7$.

(*f*) If Joule's equivalent be 24832 foot poundals when the degree Fahrenheit is unit of temperature, what will be its value when kilogramme metre second and degree-Centigrade units are used?

The conversion factor is $l^2t^{-2}\theta^{-1}$, where $l = .3048$, $t = 1$, and $\theta^{-1} = 1.8$; $\therefore$ $24832 \times l^2t^{-2}\theta^{-1} = 24832 \times .3048^2 \times 1.8 = 4152.5$.

In gravitation units this would give $4152.5/9.81 = 423.3$.

ELECTRIC AND MAGNETIC UNITS.

There are two systems of these units, the electrostatic and the electromagnetic systems, which differ from each other because of the different fundamental suppositions on which they are based. In the electrostatic system the repulsive force between two quantities of static electricity is made the basis. This connects force, quantity of electricity, and length by the equation $f = a\frac{qq_1}{l^2}$, where f is force, a a quantity depending on the units employed and on the nature of the medium, q and q_1 quantities of electricity, and l the distance between q and q_1. The magnitude of the force f for any particular values of q, q_1 and l depends on a property of the medium across which the force takes place called its inductive capacity. The inductive capacity of air has generally been assumed as unity, and the inductive capacity of other media expressed as a number representing the ratio of the inductive capacity of the medium to that of air. These numbers are known as the specific inductive capacities of the media. According to the ordinary assumption, then, of air as the standard medium, we obtain unit quantity of electricity when in the above equation $q = q_1$, and f, a, and l are each unity. A formal definition is given below.

In the electromagnetic system the repulsion between two magnetic poles or

quantities of magnetism is taken as the basis. In this system the quantities force, quantity of magnetism, and length are connected by an equation of the form

$$f = a\frac{mm_{\prime}}{l^2},$$

where m and $m_{\prime}$ are in this case quantities of magnetism, and the other symbols have the same meaning as before. In this case it has been usual to assume the magnetic inductive capacity of air to be unity, and to express the magnetic inductive capacity of other media as a simple number representing the ratio of the inductive capacity of the medium to that of air. These numbers, by analogy with specific inductive capacity for electricity, might be called specific inductive capacities for magnetism. They are usually called permeabilities. (*Vide* Thomson, "Papers on Electrostatics and Magnetism," p. 484.) In this case, also, like that for electricity, the unit quantity of magnetism is obtained by making $m = m_{\prime}$, and f, a, and l each unity.

In both these cases the intrinsic inductive capacity of the standard medium is suppressed, and hence also that of all other media. Whether this be done or not, direct experiment has to be resorted to for the determination of the absolute values of the units and the relations of the units in the one system to those in the other. The character of this relation can be directly inferred from the dimensional formulæ of the different quantities, but these can give no information as to the relative absolute values of the units in the two systems. Prof. Rücker has suggested (Phil. Mag. vol. 27) the advisability of at least indicating the existence of the suppressed properties by putting symbols for them in the dimensional formulæ. This has the advantage of showing how the magnitudes of the different units would be affected by a change in the standard medium, or by making the standard medium different for the two systems. In accordance with this idea, the symbols K and P have been introduced into the formulæ given below to represent inductive capacity in the electrostatic and the electromagnetic systems respectively. In the conversion formulæ k and p are the ordinary specific inductive capacities and permeabilities of the media when air is taken as the standard, or generally those with reference to the first medium taken as standard. The ordinary formulæ may be obtained by putting K and P equal to unity.

ELECTROSTATIC UNITS.

1. **Quantity of Electricity.** — The unit quantity of electricity is defined as that quantity which if concentrated at a point and placed at unit distance from an equal and similarly concentrated quantity repels it, or is repelled by it, with unit force. The medium or dielectric is usually taken as air, and the other units in accordance with the centimetre gramme second system.

In this case we have the force of repulsion proportional directly to the square of the quantity of electricity and inversely to the square of the distance between the quantities and to the inductive capacity. The dimensional formula is therefore the same as that for [force $\times$ length^2 $\times$ inductive capacity]$^{\frac{1}{2}}$ or $M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}K^{\frac{1}{2}}$, and the conversion factor is $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-1}k^{\frac{1}{2}}$.

2. **Electric Surface Density and Electric Displacement.** — The density of an electric distribution at any point on a surface is measured by the quantity per unit of area, and the electric displacement at any point in a dielectric is measured by the quantity displaced per unit of area. These quantities have therefore the same dimensional formula, namely, the ratio of the formulæ for quantity of electricity and for area or $M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}K^{\frac{1}{2}}$, and the conversion factor $m^{\frac{1}{2}}l^{-\frac{1}{2}}t^{-1}k^{\frac{1}{2}}$.

3. **Electric Force at a Point, or Intensity of Electric Field.** — This is measured by the ratio of the magnitude of the force on a quantity of electricity at a point to the magnitude of the quantity of electricity. The dimensional formula is therefore the ratio of the formulæ for force and electric quantity, or

$$\frac{MLT^{-2}}{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}K^{\frac{1}{2}}} = M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}K^{-\frac{1}{2}},$$

which gives the conversion factor $m^{\frac{1}{2}}l^{-\frac{1}{2}}t^{-1}k^{-\frac{1}{2}}$.

4. **Electric Potential and Electromotive Force.** — Change of potential is proportional to the work done per unit of electricity in producing the change. The dimensional formula is therefore the ratio of the formulæ for work and electric quantity, or

$$\frac{ML^{2}T^{-2}}{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}K^{\frac{1}{2}}} = M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}K^{-\frac{1}{2}},$$

which gives the conversion factor $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}k^{-\frac{1}{2}}$.

5. **Capacity of a Conductor.** — The capacity of an insulated conductor is proportional to the ratio of the numbers representing the quantity of electricity in a charge and the potential of the charge. The dimensional formula is thus the ratio of the two formulæ for electric quantity and potential, or

$$\frac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}K^{\frac{1}{2}}}{M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}K^{-\frac{1}{2}}} = LK,$$

which gives *lk* for conversion factor. When K is taken as unity, as in the ordinary units, the capacity of an insulated conductor is simply a length.

6. **Specific Inductive Capacity.** — This is the ratio of the inductive capacity of the substance to that of a standard substance, and hence the dimensional formula is K/K or 1.*

7. **Electric Current.** — Current is quantity flowing past a point per unit of time. The dimensional formula is thus the ratio of the formulæ for electric quantity and for time, or

$$\frac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}K^{\frac{1}{2}}}{T} = M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}K^{\frac{1}{2}},$$

and the conversion factor $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-2}k^{\frac{1}{2}}$.

* According to the ordinary definition referred to air as standard medium, the specific inductive capacity of a substance is K, or is identical in dimensions with what is here taken as inductive capacity. Hence in that case the conversion factor must be taken as 1 on the electrostatic and as $l^{-2}t^{2}$ on the electromagnetic system.

8. **Conductivity, or Specific* Conductance.** — This, like the corresponding term for heat, is quantity per unit area per unit potential gradient per unit of time. The dimensional formula is therefore

$$\frac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}K^{\frac{1}{2}}}{L^2\dfrac{M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}K^{-\frac{1}{2}}}{L}T} = T^{-1}K, \text{ or } \frac{\text{electric quantity}}{\text{area} \times \text{potential gradient} \times \text{time}}.$$

The conversion factor is $t^{-1}k$.

9. **Specific* Resistance.** — This is the reciprocal of conductivity as above defined, and hence the dimensional formula and conversion factor are respectively TK^{-1} and tk^{-1}.

10. **Conductance.** — The conductance of any part of an electric circuit, not containing a source of electromotive force, is the ratio of the numbers representing the current flowing through it and the difference of potential between its ends. The dimensional formula is thus the ratio of the formulæ for current and potential, or

$$\frac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}K^{\frac{1}{2}}}{M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}K^{-\frac{1}{2}}} = LT^{-1}K,$$

from which we get the conversion factor $lt^{-1}k$.

11. **Resistance.**—This is the reciprocal of conductance, and therefore the dimensional formula and the conversion factor are respectively $L^{-1}TK^{-1}$ and $l^{-1}tk^{-1}$.

EXAMPLES OF CONVERSION IN ELECTROSTATIC UNITS.

(*a*) Find the factor for converting quantity of electricity expressed in foot grain second units to the same expressed in c. g. s. units.

By (1) the formula is $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-1}k^{\frac{1}{2}}$, in which in this case $m = 0.0648$, $l = 30.48$, $t = 1$, and $k = 1$; $\therefore$ the factor is $0.0648^{\frac{1}{2}} \times 30.48^{\frac{3}{2}} = 4.2836$.

(*b*) Find the factor required to convert electric potential from millimetre milligramme second units to c. g. s. units.

By (4) the formula is $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}k^{-\frac{1}{2}}$, and in this case $m = 0.001$, $l = 0.1$, $t = 1$, and $k = 1$; $\therefore$ the factor $= 0.001^{\frac{1}{2}} \times 0.1^{\frac{1}{2}} = 0.01$.

(*c*) Find the factor required to convert from foot grain second and specific inductive capacity 6 units to c. g. s. units.

By (5) the formula is lk, and in this case $l = 30.48$ and $k = 6$; $\therefore$ the factor $= 30.48 \times 6 = 182.88$.

* The term "specific," as used here and in 9, refers conductance and resistance to that between the ends of a bar of unit section and unit length, and hence is different from the same term in specific heat, specific inductivity, capacity, etc., which refer to a standard substance.

ELECTROMAGNETIC UNITS.

As stated above, these units bear the same relation to unit quantity of magnetism that the electric units do to quantity of electricity. Thus, when inductive capacity is suppressed, the dimensional formula for magnetic quantity on this system is the same as that for electric quantity on the electrostatic system. All quantities in this system which only differ from corresponding quantities defined above by the substitution of magnetic for electric quantity may have their dimensional formulæ derived from those of the corresponding quantity by substituting P for K.

1. **Magnetic Pole, or Quantity of Magnetism.** — Two unit quantities of magnetism concentrated at points unit distance apart repel each other with unit force. The dimensional formula is thus the same as for [force × length^2 × inductive capacity] or $M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}P^{\frac{1}{2}}$, and the conversion factor is $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-1}p^{\frac{1}{2}}$.

2. **Density of Surface Distribution of Magnetism.** — This is measured by quantity of magnetism per unit area, and the dimension formula is therefore the ratio of the expressions for magnetic quantity and for area, or $M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}P^{\frac{1}{2}}$, which gives the conversion factor $m^{\frac{1}{2}}l^{-\frac{1}{2}}t^{-1}p^{\frac{1}{2}}$.

3. **Magnetic Force at a Point, or Intensity of Magnetic Field.** — The number for this is the ratio of the numbers representing the magnitudes of the force on a magnetic pole placed at the point and the magnitude of the magnetic pole.

The dimensional formula is therefore the ratio of the expressions for force and magnetic quantity, or

$$\frac{MLT^{-2}}{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}P^{\frac{1}{2}}} = M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}P^{-\frac{1}{2}},$$

and the conversion factor $m^{\frac{1}{2}}l^{-\frac{1}{2}}t^{-1}p^{-\frac{1}{2}}$.

4. **Magnetic Potential.** — The magnetic potential at a point is measured by the work which is required to bring unit quantity of positive magnetism from zero potential to the point. The dimensional formula is thus the ratio of the formula for work and magnetic quantity, or

$$\frac{ML^2T^{-2}}{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}P^{\frac{1}{2}}} = M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{-\frac{1}{2}},$$

which gives the conversion factor $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}p^{-\frac{1}{2}}$.

5. **Magnetic Moment.** — This is the product of the numbers for pole strength and length of a magnet. The dimensional formula is therefore the product of the formulæ for magnetic quantity and length, or $M^{\frac{1}{2}}L^{\frac{5}{2}}T^{-1}P^{\frac{1}{2}}$, and the conversion factor $m^{\frac{1}{2}}l^{\frac{5}{2}}t^{-1}p^{\frac{1}{2}}$.

6. **Intensity of Magnetization.** — The intensity of magnetization of any portion of a magnetized body is the ratio of the numbers representing the magni-

tude of the magnetic moment of that portion and its volume. The dimensional formula is therefore the ratio of the formulæ for magnetic moment and volume, or

$$\frac{M^{\frac{1}{2}}L^{\frac{5}{2}}T^{-1}P^{\frac{1}{2}}}{L^3} = M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}P^{\frac{1}{2}}.$$

The conversion factor is therefore $m^{\frac{1}{2}}l^{-\frac{1}{2}}t^{-1}p^{\frac{1}{2}}$.

7. **Magnetic Permeability,* or Specific Magnetic Inductive Capacity.** — This is the analogue in magnetism to specific inductive capacity in electricity. It is the ratio of the magnetic induction in the substance to the magnetic induction in the field which produces the magnetization, and therefore its dimensional formula and conversion factor are unity.

8. **Magnetic Susceptibility.** — This is the ratio of the numbers which represent the values of the intensity of magnetization produced and the intensity of the magnetic field producing it. The dimensional formula is therefore the ratio of the formulæ for intensity of magnetization and magnetic field or

$$\frac{M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}P^{\frac{1}{2}}}{M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}P^{-\frac{1}{2}}} \text{ or } P.$$

The conversion factor is therefore p, and both the dimensional formula and conversion factor are unity in the ordinary system.

9. **Current Strength.** — A current of strength c flowing round a circle of radius r produces a magnetic field at the centre of intensity $2\pi c/r$. The dimensional formula is therefore the product of the formulæ for magnetic field intensity and length, or $M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{-\frac{1}{2}}$, which gives the conversion factor $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}p^{-\frac{1}{2}}$.

10. **Current Density, or Strength of Current at a Point.** — This is the ratio of the numbers for current strength and area. The dimensional formula and the conversion factor are therefore $M^{\frac{1}{2}}L^{-\frac{3}{2}}T^{-1}P^{-\frac{1}{2}}$ and $m^{\frac{1}{2}}l^{-\frac{3}{2}}t^{-1}p^{-\frac{1}{2}}$.

11. **Quantity of Electricity.** — This is the product of the numbers for current and time. The dimensional formula is therefore $M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{-\frac{1}{2}} \times T = M^{\frac{1}{2}}L^{\frac{1}{2}}P^{-\frac{1}{2}}$, and the conversion factor $m^{\frac{1}{2}}l^{\frac{1}{2}}p^{-\frac{1}{2}}$.

12. **Electric Potential, or Electromotive Force.** — As in the electrostatic system, this is the ratio of the numbers for work and quantity of electricity. The dimensional formula is therefore

$$\frac{ML^2T^{-2}}{M^{\frac{1}{2}}L^{\frac{1}{2}}P^{-\frac{1}{2}}} = M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}P^{\frac{1}{2}},$$

and the conversion factor $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-2}p^{\frac{1}{2}}$.

* Permeability, as ordinarily taken with the standard medium as unity, has the same dimension formula and conversion factor as that which is here taken as magnetic inductive capacity. Hence for ordinary transformations the conversion factor should be taken as 1 in the electromagnetic and $l^{-2}t^2$ in the electrostatic systems.

13. **Electrostatic Capacity.** — This is the ratio of the numbers for quantity of electricity and difference of potential. The dimensional formula is therefore

$$\frac{M^{\frac{1}{2}}L^{\frac{1}{2}}P^{-\frac{1}{2}}}{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}P^{\frac{1}{2}}} = L^{-1}T^{2}P^{-1},$$

and the conversion factor $l^{-1}t^{2}p^{-1}$.

14. **Resistance of a Conductor.** — The resistance of a conductor or electrode is the ratio of the numbers for difference of potential between its ends and the constant current it is capable of producing. The dimensional formula is therefore the ratio of those for potential and current or

$$\frac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}P^{\frac{1}{2}}}{M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{-\frac{1}{2}}} = LT^{-1}P.$$

The conversion factor thus becomes $lt^{-1}p$, and in the ordinary system resistance has the same conversion factor as velocity.

15. **Conductance.** — This is the reciprocal of resistance, and hence the dimensional formula and conversion factor are respectively $L^{-1}TP^{-1}$ and $l^{-1}tp^{-1}$.

16. **Conductivity, or Specific Conductance.** — This is quantity of electricity transmitted per unit of area per unit of potential gradient per unit of time. The dimensional formula is therefore derived from those of the quantities mentioned as follows: —

$$\frac{M^{\frac{1}{2}}L^{\frac{1}{2}}P^{-\frac{1}{2}}}{L^{2}\dfrac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}P^{\frac{1}{2}}}{L}T} = L^{-2}TP^{-1}.$$

The conversion factor is therefore $l^{-2}tp^{-1}$.

17. **Specific Resistance.** — This is the reciprocal of conductivity as defined in 15, and hence the dimensional formula and conversion factor are respectively $L^{2}T^{-1}P$ and $l^{2}t^{-1}p$.

18. **Coefficient of Self-Induction, or Inductance, or Electro-kinetic Inertia.** — These are for any circuit the electromotive force produced in it by unit rate of variation of the current through it. The dimensional formula is therefore the product of the formulæ for electromotive force and time divided by that for current or

$$\frac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}P^{\frac{1}{2}}}{M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{-\frac{1}{2}}} \times T = LP.$$

The conversion factor is therefore lp, and in the ordinary system is the same as that for length.

19. **Coefficient of Mutual Induction.** — The mutual induction of two circuits is the electromotive force produced in one per unit rate of variation of the current in the other. The dimensional formula and the conversion factor are therefore the same as those for self-induction.

20. **Electro-kinetic Momentum.** — The number for this is the product of the numbers for current and for electro-kinetic inertia. The dimensional formula is therefore the product of the formulæ for these quantities, or $M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{-\frac{1}{2}} \times LP = M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}P^{\frac{1}{2}}$, and the conversion factor is $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-1}p^{\frac{1}{2}}$.

21. **Electromotive Force at a Point.** — The number for this quantity is the ratio of the numbers for electric potential or electromotive force as given in 12, and for length. The dimensional formula is therefore $M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-2}P^{\frac{1}{2}}$, and the conversion factor $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-2}p^{\frac{1}{2}}$.

22. **Vector Potential.** — This is time integral of electromotive force at a point, or the electro-kinetic momentum at a point. The dimensional formula may therefore be derived from 21 by multiplying by T, or from 20 by dividing by L. It is therefore $M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{\frac{1}{2}}$, and the conversion factor $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}p^{\frac{1}{2}}$.

23. **Thermoelectric Height.** — This is measured by the ratio of the numbers for electromotive force and for temperature. The dimensional formula is therefore the ratio of the formulæ for these two quantities, or $M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}P^{\frac{1}{2}}\Theta^{-1}$, and the conversion factor $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-2}p^{\frac{1}{2}}\theta^{-1}$.

24. **Specific Heat of Electricity.** — This quantity is measured in the same way as 23, and hence has the same formulæ.

25. **Coefficient of Peltier Effect.** — This is measured by the ratio of the numbers for quantity of heat and for quantity of electricity. The dimensional formula is therefore

$$\frac{M\Theta}{M^{\frac{1}{2}}L^{\frac{1}{2}}P^{-\frac{1}{2}}} = M^{\frac{1}{2}}L^{-\frac{1}{2}}P^{\frac{1}{2}}\Theta,$$

and the conversion factor $m^{\frac{1}{2}}l^{-\frac{1}{2}}p^{\frac{1}{2}}\theta$.

EXAMPLES OF CONVERSION IN ELECTROMAGNETIC UNITS.

(*a*) Find the factor required to convert intensity of magnetic field from foot grain minute units to c. g. s. units.

By (3) the formula is $m^{\frac{1}{2}}l^{-\frac{1}{2}}t^{-1}p^{-\frac{1}{2}}$, and in this case $m = 0.0648$, $l = 30.48$, $t = 60$, and $p = 1$; $\therefore$ the factors $= 0.0648^{\frac{1}{2}} \times 30.48^{-\frac{1}{2}} \times 60^{-1} = 0.00076847$.

Similarly to convert from foot grain second units to c. g. s. units the factor is $0.0648^{\frac{1}{2}} \times 30.48^{-\frac{1}{2}} = 0.046108$.

(*b*) How many c. g. s. units of magnetic moment make one foot grain second unit of the same quantity?

By (5) the formula is $m^{\frac{1}{2}}l^{\frac{5}{2}}t^{-1}p^{\frac{1}{2}}$, and the values for this problem are $m = 0.0648$, $l = 30.48$, $t = 1$, and $p = 1$; $\therefore$ the number $= 0.0648^{\frac{1}{2}} \times 30.48^{\frac{5}{2}} = 1305.6$.

(*c*) If the intensity of magnetization of a steel bar be 700 in c. g. s. units, what will it be in millimetre milligramme second units?

By (6) the formula is $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}p^{\frac{1}{2}}$, and in this case $m = 1000$, $l = 10$, $t = 1$, and $p = 1$; $\therefore$ the intensity $= 700 \times 1000^{\frac{1}{2}} \times 10^{\frac{1}{2}} = 70000$.

(d) Find the factor required to convert current strength from c. g. s. units to earth quadrant 10^{-11} gramme and second units.

By (9) the formula is $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}p^{-\frac{1}{2}}$, and the values of these quantities are here $m = 10^{11}$, $l = 10^{-9}$, $t = 1$, and $p = 1$; $\therefore$ the factor $= 10^{\frac{11}{2}} \times 10^{-\frac{9}{2}} = 10$.

(e) Find the factor required to convert resistance expressed in c. g. s. units into the same expressed in earth-quadrant 10^{-11} grammes and second units.

By (14) the formula is $lt^{-1}p$, and for this case $l = 10^{-9}$, $t = 1$, and $p = 1$; $\therefore$ the factor $= 10^{-9}$.

(f) Find the factor required to convert electromotive force from earth-quadrant 10^{-11} gramme and second units to c. g. s. units.

By (12) the formula is $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-2}p^{\frac{1}{2}}$, and for this case $m = 10^{-11}$, $l = 10^{9}$, $t = 1$, and $p = 1$; $\therefore$ the factor $= 10^{8}$.

PRACTICAL UNITS.

In practical electrical measurements the units adopted are either multiples or submultiples of the units founded on the centimetre, the gramme, and the second as fundamental units, and air is taken as the standard medium, for which K and P are assumed unity. The following, quoted from the report to the Honorable the Secretary of State, under date of November 6th, 1893, by the delegates representing the United States, gives the ordinary units with their names and values as defined by the International Congress at Chicago in 1893: —

"*Resolved*, That the several governments represented by the delegates of this International Congress of Electricians be, and they are hereby, recommended to formally adopt as legal units of electrical measure the following: As a unit of resistance, the *international ohm*, which is based upon the ohm equal to 10^9 units of resistance of the C. G. S. system of electro-magnetic units, and is represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice 14.4521 grammes in mass, of a constant cross-sectional area and of the length of 106.3 centimetres.

"As a unit of current, the *international ampère*, which is one tenth of the unit of current of the C. G. S. system of electro-magnetic units, and which is represented sufficiently well for practical use by the unvarying current which, when passed through a solution of nitrate of silver in water, and in accordance with accompanying specifications,* deposits silver at the rate of 0.001118 of a gramme per second.

* "In the following specification the term 'silver voltameter' means the arrangement of apparatus by means of which an electric current is passed through a solution of nitrate of silver in water. The silver voltameter measures the total electrical quantity which has passed during the time of the experiment, and by noting this time the time average of the current, or, if the current has been kept constant, the current itself can be deduced.

"In employing the silver voltameter to measure currents of about one ampère, the following arrangements should be adopted: —

"As a unit of electromotive force, the *international volt*, which is the electromotive force that, steadily applied to a conductor whose resistance is one international ohm, will produce a current of one international ampère, and which is represented sufficiently well for practical use by $\frac{1000}{1434}$ of the electromotive force between the poles or electrodes of the voltaic cell known as Clark's cell, at a temperature of 15° C., and prepared in the manner described in the accompanying specification.*

"As a unit of quantity, the *international coulomb*, which is the quantity of electricity transferred by a current of one international ampère in one second.

"As a unit of capacity, the *international farad*, which is the capacity of a condenser charged to a potential of one international volt by one international coulomb of electricity.†

"As a unit of work, the *joule*, which is equal to 10^7 units of work in the c. g. s. system, and which is represented sufficiently well for practical use by the energy expended in one second by an international ampère in an international ohm.

"As a unit of power, the *watt*, which is equal to 10^7 units of power in the c. g. s. system, and which is represented sufficiently well for practical use by the work done at the rate of one joule per second.

"As the unit of induction, the *henry*, which is the induction in a circuit when the electromotive force induced in this circuit is one international volt, while the inducing current varies at the rate of one ampère per second.

"The Chamber also voted that it was not wise to adopt or recommend a standard of light at the present time."

By an Act of Congress approved July 12th, 1894, the units recommended by the Chicago Congress were adopted in this country with only some unimportant verbal changes in the definitions.

By an Order in Council of date August 23d, 1894, the British Board of Trade adopted the ohm, the ampere, and the volt, substantially as recommended by the Chicago Congress. The other units were not legalized in Great Britain. They are, however, in general use in that country and all over the world.

"The kathode on which the silver is to be deposited should take the form of a platinum bowl not less than 10 centimetres in diameter and from 4 to 5 centimetres in depth.

"The anode should be a plate of pure silver some 30 square centimetres in area and 2 or 3 millimetres in thickness.

"This is supported horizontally in the liquid near the top of the solution by a platinum wire passed through holes in the plate at opposite corners. To prevent the disintegrated silver which is formed on the anode from falling on to the kathode, the anode should be wrapped round with pure filter paper, secured at the back with sealing wax.

"The liquid should consist of a neutral solution of pure silver nitrate, containing about 15 parts by weight of the nitrate to 85 parts of water.

"The resistance of the voltameter changes somewhat as the current passes. To prevent these changes having too great an effect on the current, some resistance besides that of the voltameter should be inserted in the circuit. The total metallic resistance of the circuit should not be less than 10 ohms."

* "A committee, consisting of Messrs. Helmholtz, Ayrton, and Carhart, was appointed to prepare specifications for the Clark's cell. Their report has not yet been received."

† The one millionth part of the farad is more commonly used in practical measurements, and is called the microfarad.

PHYSICAL TABLES

FUNDAMENTAL AND DERIVED UNITS.

(*a*) Fundamental Units.

Name of Unit.	Symbol.	Conversion Factor.
Length.	L	l
Mass.	M	m
Time.	T	t
Temperature.	Θ	θ
Electric Inductive Capacity.	K	k
Magnetic Inductive Capacity.	P	p

(*b*) Derived Units.

I. Geometric and Dynamic Units.

Name of Unit.	Conversion Factor.
Area.	l^2
Volume.	l^3
Angle.	1
Solid Angle.	1
Curvature.	l^{-1}
Tortuosity.	l^{-1}
Specific curvature of a surface.	l^{-2}
Angular velocity.	t^{-1}
Angular acceleration.	$l\,t^{-2}$
Linear velocity.	$l\,t^{-1}$
Linear acceleration.	$l\,t^{-2}$
Density.	$m\,l^{-3}$
Moment of inertia.	$m\,l^2$
Intensity of attraction, or "force at a point."	$l\,t^{-2}$
Absolute force of a centre of attraction, or "strength of a centre."	$l^3\,t^{-2}$
Momentum.	$m\,l\,t^{-1}$
Moment of momentum, or angular momentum.	$m\,l^2\,t^{-1}$
Force.	$m\,l\,t^{-2}$
Moment of a couple, or torque.	$m\,l^2\,t^{-2}$
Intensity of stress.	$m\,l^{-1}\,t^{-2}$
Modulus of elasticity.	$m\,l^{-1}\,t^{-2}$
Work and energy.	$m\,l^2\,t^{-2}$
Resilience.	$m\,l^{-1}\,t^{-2}$
Power or activity.	$m\,l^2\,t^{-3}$

FUNDAMENTAL AND DERIVED UNITS.

II. Heat Units.

Name of Unit.	Conversion Factor.
Quantity of heat (thermal units).	$m\,\theta$
" " (thermometric units).	$l^3\,\theta$
" " (dynamical units).	$m\,l^2\,t^{-2}$
Coefficient of thermal expansion.	θ^{-1}
Conductivity (thermal units).	$m\,l^{-1}\,t^{-1}$
" (thermometric units), or diffusivity.	$l^2\,t^{-1}$
" (dynamical units).	$m\,l\,t^{-3}\,\theta^{-1}$
Emissivity and imissivity (thermal units).	$m\,l^{-2}\,t^{-1}$
" " (thermometric units).	$l\,t^{-1}$
" " (dynamical units).	$m\,t^{-3}\,\theta^{-1}$
Thermal capacity.	m
Latent heat (thermal units).	θ
" " (dynamical units).	$l^2\,t^{-2}$
Joule's equivalent.	$l^2\,t^{-2}\,\theta^{-1}$
Entropy (heat measured in thermal units).	m
" (" " dynamical units).	$m\,l^2\,t^{-2}\,\theta^{-1}$

III. Magnetic and Electric Units.

Name of Unit.	Conversion factor for electrostatic system.	Conversion factor for electromagnetic system.
Magnetic pole, or quantity of magnetism.	$m^{\frac{1}{2}}\,l^{\frac{1}{2}}\,k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{\frac{3}{2}}\,t^{-1}\,p^{\frac{1}{2}}$
Density of surface distribution of magnetism.	$m^{\frac{1}{2}}\,l^{-\frac{3}{2}}\,k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{-\frac{1}{2}}\,t^{-1}\,p^{\frac{1}{2}}$
Intensity of magnetic field.	$m^{\frac{1}{2}}\,l^{\frac{1}{2}}\,t^{-2}\,k^{\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{-\frac{1}{2}}\,t^{-1}\,p^{-\frac{1}{2}}$
Magnetic potential.	$m^{\frac{1}{2}}\,l^{\frac{3}{2}}\,t^{-2}\,k^{\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{\frac{1}{2}}\,t^{-1}\,p^{-\frac{1}{2}}$
Magnetic moment.	$m^{\frac{1}{2}}\,l^{\frac{3}{2}}\,k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{\frac{5}{2}}\,t^{-1}\,p^{\frac{1}{2}}$
Intensity of magnetisation.	$m^{\frac{1}{2}}\,l^{\frac{1}{2}}\,k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{-\frac{1}{2}}\,t^{-1}\,p^{\frac{1}{2}}$
Magnetic permeability.	1	1
Magnetic susceptibility and magnetic inductive capacity.	$l^{-2}\,t^2\,k^{-1}$	p
Quantity of electricity.	$m^{\frac{1}{2}}\,l^{\frac{3}{2}}\,t^{-1}\,k^{\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{\frac{1}{2}}\,p^{-\frac{1}{2}}$
Electric surface density and electric displacement.	$m^{\frac{1}{2}}\,l^{-\frac{1}{2}}\,t^{-1}\,k^{\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{-\frac{3}{2}}\,p^{-\frac{1}{2}}$
Intensity of electric field.	$m^{\frac{1}{2}}\,l^{-\frac{1}{2}}\,t^{-1}\,k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{\frac{1}{2}}\,t^{-2}\,p^{\frac{1}{2}}$
Electric potential and e. m. f.	$m^{\frac{1}{2}}\,l^{\frac{1}{2}}\,t^{-1}\,k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{\frac{3}{2}}\,t^{-2}\,p^{\frac{1}{2}}$
Capacity of a condenser.	$l\,k$	$l^{-1}\,t^2\,p^{-1}$
Inductive capacity.	k	$l^{-2}\,t^2\,p^{-1}$
Specific inductive capacity.	1	1
Electric current.	$m^{\frac{1}{2}}\,l^{\frac{3}{2}}\,t^{-2}\,k^{\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{\frac{1}{2}}\,t^{-1}\,p^{-\frac{1}{2}}$

FUNDAMENTAL AND DERIVED UNITS.

III. Magnetic and Electric Units.

Name of Unit.	Conversion factor for electrostatic system.	Conversion factor for electromagnetic system.
Conductivity.	$t^{-1}\,k$	$l^{-2}\,t\,p^{-1}$
Specific resistance.	$t\,k^{-1}$	$l^{2}\,t^{-1}\,p$
Conductance.	$l\,t^{-1}\,k$	$l^{-1}\,t\,p^{-1}$
Resistance.	$l^{-1}\,t\,k^{-1}$	$l\,t^{-1}\,p$
Coefficient of self induction and coefficient of mutual induction.	$l^{-1}\,t^{2}\,k^{-1}$	$l\,p$
Electrokinetic momentum.	$m^{\frac{1}{2}}\,l^{\frac{1}{2}}\,k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{\frac{3}{2}}\,t^{-1}\,p^{\frac{1}{2}}$
Electromotive force at a point.	$m^{\frac{1}{2}}\,l^{-\frac{1}{2}}\,t^{-1}\,k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{\frac{1}{2}}\,t^{-2}\,p^{\frac{1}{2}}$
Vector potential.	$m^{\frac{1}{2}}\,l^{-\frac{1}{2}}\,k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\,l^{\frac{1}{2}}\,t^{-1}\,p^{\frac{1}{2}}$
Thermoelectric height and specific heat of electricity.	$m^{\frac{1}{2}}\,l^{\frac{1}{2}}\,t^{-1}\,k^{-\frac{1}{2}}\,\theta^{-1}$	$m^{\frac{1}{2}}\,l^{\frac{3}{2}}\,t^{-2}\,p^{\frac{1}{2}}\,\theta^{-1}$
Coefficient of Peltier effect.	$m^{\frac{1}{2}}\,l^{-\frac{3}{2}}\,t\,k^{-\frac{1}{2}}\,\theta$	$m^{\frac{1}{2}}\,l^{-\frac{1}{2}}\,p^{\frac{1}{2}}\,\theta$

EQUIVALENTS OF METRIC AND BRITISH IMPERIAL WEIGHTS AND MEASURES.*

(1) METRIC TO IMPERIAL.

LINEAR MEASURE.

1 millimetre (mm.) (.001 m.) =	0.03937 in.
1 centimetre (.01 m.) =	0.39370 "
1 decimetre (.1 m.) =	3.93701 "
1 METRE (m.) . . =	39.370113 " 3.280843 ft. 1.0936143 yds.
1 dekametre (10 m.) . . =	10.93614 "
1 hectometre (100 m.) . . =	109.36143 "
1 kilometre (1,000 m.) . . =	0.62137 mile.
1 myriametre (10,000 m.) . . =	6.21372 miles.
1 micron . . . . =	0.001 mm.

SQUARE MEASURE.

1 sq. centimetre . . =	0.1550 sq. in.
1 sq. decimetre (100 sq. centm.) =	15.500 sq. in.
1 sq. metre or centiare (100 sq. dcm.) =	10.7639 sq. ft. 1.1960 sq. yd.
1 ARE (100 sq. m.) =	119.60 sq. yds.
1 hectare (100 ares or 10,000 sq. m.) =	2.4711 acres.

CUBIC MEASURE.

1 cub. centimetre (c.c.) (1,000 cubic millimetres) =	0.0610 cub. in
1 cub. decimetre (c.d.) (1,000 cubic centimetres) =	61.024 " "
1 CUB. METRE or stere . (1,000 c.d.) =	35.3148 cub. ft. 1.307954 cub. yd.

MEASURE OF CAPACITY.

1 millilitre (ml.) (.001 litre) =	0.0610 cub. in.
1 centilitre (.01 litre) =	0.61024 " " 0.070 gill.
1 decilitre (.1 litre) . . =	0.176 pint.
1 LITRE (1,000 cub. centimetres or 1 cub. decimetre) =	1.75980 pints.
1 dekalitre (10 litres) . =	2.200 gallons.
1 hectolitre (100 ") . =	2.75 bushels.
1 kilolitre (1,000 ") . =	3.437 quarters.

APOTHECARIES' MEASURE.

1 cubic centimetre (1 gramme w't) =	0.03527 fluid ounce. 0.28219 fluid drachm. 15.43235 grains weight.
1 cub. millimetre =	0.01693 minim.

AVOIRDUPOIS WEIGHT.

1 milligramme (mgr.) . =	0.01543 grain.
1 centigramme (.01 gram.) =	0.15432 "
1 decigramme (.1 ") =	1.54324 grains.
1 GRAMME . . . . . =	15.43235 "
1 dekagramme (10 gram.) =	5.64383 drams.
1 hectogramme (100 ") =	3.52739 oz.
1 KILOGRAMME (1,000 ") =	2.2046223 lb. 15432.3564 grains.
1 myriagramme (10 kilog.) =	22.04621 lb.
1 quintal (100 ") =	1 96841 cwt.
1 millier or tonne (1,000 kilog.) . . =	0.9842 ton.

TROY WEIGHT.

1 GRAMME . . =	0.03215 oz. Troy. 0.64301 pennyweight. 15.43236 grains.

APOTHECARIES' WEIGHT.

1 GRAMME . . . . =	0.25721 drachm. 0.77162 scruple. 15.43235 grains.

NOTE.—The METRE is the length, at the temperature of 0° C., of the platinum-iridium bar deposited with the Board of Trade.

The present legal equivalent of the metre is 39.370113 inches, as above stated. If a brass metre is, however, compared, not at its legal temperature (0° C. or 32°F.), but at the temperature of 62° F., with a brass yard at the temperature also of 62° F., then the apparent equivalent of the metre would be nearly 39.382 inches.

The KILOGRAMME is the weight in vacuo at 0° C. of the platinum-iridium weight deposited with the Board of Trade.

The LITRE contains one kilogramme weight of distilled water at its maximum density (4° C.), the barometer being at 760 millimetres.

*In accordance with the schedule adopted under the Weights and Measures (metric system) Act, 1897.

Table 2.

EQUIVALENTS OF METRIC AND BRITISH IMPERIAL WEIGHTS AND MEASURES.

(2) METRIC TO IMPERIAL.

LINEAR MEASURE.

	Millimetres to inches.	Metres to feet.	Metres to yards.	Kilometres to miles.
1	0.03937011	3.28084	1.09361	0.62137
2	0.07874023	6.56169	2.18723	1.24274
3	0.11811034	9.84253	3.28084	1.86412
4	0.15748045	13.12337	4.37446	2.48549
5	0.19685056	16.40421	5.46807	3.10686
6	0.23622068	19.68506	6.56169	3.72823
7	0.27559079	22.96590	7.65530	4.34760
8	0.31496090	26.24674	8.74891	4.97098
9	0.35433102	29.52759	9.84253	5.59235

MEASURE OF CAPACITY.

	Litres to pints.	Dekalitres to gallons.	Hectolitres to bushels.	Kilolitres to quarters.
1	1.75980	2.19975	2.74969	3.43712
2	3.51961	4.39951	5.49938	6.87423
3	5.27941	6.59926	8.24908	10.31135
4	7.03921	8.79902	10.99877	13.74846
5	8.79901	10.99877	13.74846	17.18558
6	10.55882	13.19852	16.49815	20.62269
7	12.31862	15.39828	19.24785	24.05981
8	14.07842	17.59803	21.99754	27.49692
9	15.83822	19.79778	24.74723	30.93404

SQUARE MEASURE.

	Square centimetres to square inches.	Square metres to square feet.	Square metres to square yards.	Hectares to acres.
1	0.15500	10.76393	1.19599	2.4711
2	0.31000	21.52786	2.39198	4.9421
3	0.46500	32.29179	3.58798	7.4132
4	0.62000	43.05572	4.78397	9.8842
5	0.77500	53.81965	5.97996	12.3553
6	0.93000	64.58358	7.17595	14.8264
7	1.08500	75.34751	8.37195	17.2974
8	1.24000	86.11144	9.56794	19.7685
9	1.39501	96.87537	10.76393	22.2395

WEIGHT (Avoirdupois).

	Milligrammes to grains.	Kilogrammes to grains.	Kilogrammes to pounds.	Quintals to hundredweights.
1	0.01543	15432.356	2.20462	1.96841
2	0.03086	30864.713	4.40924	3.93683
3	0.04630	46297.069	6.61386	5.90524
4	0.06173	61729.426	8.81849	7.87365
5	0.07716	77161.782	11.02311	9.84206
6	0.09259	92594.138	13.22773	11.81048
7	0.10803	108026.495	15.43235	13.77889
8	0.12346	123458.851	17.63698	15.74730
9	0.13889	138891.208	19.84160	17.71572

	CUBIC MEASURE.			Apothecaries' Measure.
	Cubic decimetres to cubic inches.	Cubic metres to cubic feet.	Cubic metres to cubic yards.	Cub. centimetres to fluid drachms.
1	61.02390	35.31476	1.30795	0.28157
2	122.04781	70.62952	2.61591	0.56314
3	183.07171	105.94427	3.92386	0.84471
4	244.09561	141.25903	5.23182	1.12627
5	305.11952	176.57379	6.53977	1.40784
6	366.14342	211.88855	7.84772	1.68941
7	427.16732	247.20331	9.15568	1.97098
8	488.19122	282.51806	10.46363	2.25255
9	549.21513	317.83282	11.77159	2.53412

	Avoirdupois (*cont.*)	Troy Weight.		Apothecaries' Weight.
	Milliers or tonnes to tons.	Grammes to ounces Troy.	Grammes to pennyweights.	Grammes to scruples.
1	0.98421	0.03215	0.64301	0.77162
2	1.96841	0.06430	1.28603	1.54323
3	2.95262	0.09645	1.92904	2.31485
4	3.93682	0.12860	2.57206	3.08647
5	4.92103	0.16075	3.21507	3.85809
6	5.90524	0.19290	3.85809	4.62970
7	6.88944	0.22506	4.50110	5.40131
8	7.87365	0.25721	5.14412	6.17294
9	8.85785	0.28936	5.78713	6.94455

EQUIVALENTS OF BRITISH IMPERIAL AND METRIC WEIGHTS AND MEASURES.

(3) IMPERIAL TO METRIC.

LINEAR MEASURE.

1 inch . . . . . =	25.400 millimetres.
1 foot (12 in.) . . =	0.30480 metre.
1 YARD (3 ft.) . . =	0.914399 "
1 pole ($5\frac{1}{2}$ yd.) . . =	5.0292 metres.
1 chain (22 yd. or 100 links) =	20.1168 "
1 furlong (220 yd.) =	201.168 "
1 mile (1,760 yd.) . =	1.6093 kilometres.

SQUARE MEASURE.

1 square inch . . =	6.4516 sq. centimetres.
1 sq. ft. (144 sq. in.) =	9.2903 sq. decimetres.
1 SQ. YARD (9 sq. ft.) =	0.836126 sq. metres.
1 perch ($30\frac{1}{4}$ sq. yd.) =	25.293 sq. metres.
1 rood (40 perches) =	10.117 ares.
1 ACRE (4840 sq. yd.) =	0.40468 hectare.
1 sq. mile (640 acres) =	259.00 hectares.

CUBIC MEASURE.

1 cub. inch =	16.387 cub. centimetres.
1 cub. foot (1728 cub. in.) =	0.0283317 cub. metre, or 28.317 cub. decimetres.
1 CUB. YARD (27 cub. ft.) =	0.76453 cub. metre.

APOTHECARIES' MEASURE.

1 gallon (8 pints or 160 fluid ounces) =	4.5459631 litres.
1 fluid ounce, f ℥ (8 drachms) =	28.4123 cubic centimetres.
1 fluid drachm, f ʒ (60 minims) =	3.5552 cubic centimetres.
1 minim, ♏ (0.91146 grain weight) =	0.05925 cubic centimetres.

NOTE. — The Apothecaries' gallon is of the same capacity as the Imperial gallon.

MEASURE OF CAPACITY.

1 gill . . . . . . =	1.42 decilitres.
1 pint (4 gills) . . . =	0.568 litre.
1 quart (2 pints) . . =	1.136 litres.
1 GALLON (4 quarts) =	4.5459631 "
1 peck (2 galls.) . . =	9.092 "
1 bushel (8 galls.) . =	3.637 dekalitres.
1 quarter (8 bushels) =	2.909 hectolitres.

AVOIRDUPOIS WEIGHT.

1 grain . . . . . =	64.8 milligrammes.
1 dram . . . . . =	1.772 grammes.
1 ounce (16 dr.) . . =	28.350 "
1 POUND (16 oz. or 7,000 grains) =	0.45359243 kilogr.
1 stone (14 lb.) . . =	6.350 "
1 quarter (28 lb.) . =	12.70 "
1 hundredweight (112 lb.) =	50.80 " / 0.5080 quintal.
1 ton (20 cwt.) . =	1.0160 tonnes or 1016 kilogrammes.

TROY WEIGHT.

1 Troy OUNCE (480 grains avoir.) =	31.1035 grammes.
1 pennyweight (24 grains) =	1.5552 "

NOTE. — The Troy grain is of the same weight as the Avoirdupois grain.

APOTHECARIES' WEIGHT.

1 ounce (8 drachms) =	31.1035 grammes.
1 drachm, ʒ i (3 scruples) =	3.888 "
1 scruple, ℈ i (20 grains) =	1.296 "

NOTE. — The Apothecaries' ounce is of the same weight as the Troy ounce. The Apothecaries' grain is also of the same weight as the Avoirdupois grain.

NOTE. — The YARD is the length at 62° Fahr., marked on a bronze bar deposited with the Board of Trade.

The POUND is the weight of a piece of platinum weighed in vacuo at the temperature of 0° C., and which is also deposited with the Board of Trade.

The GALLON contains 10 lb. weight of distilled water at the temperature of 62° Fahr., the barometer being at 30 inches. The weight of a cubic inch of water is 252.286 grains.

Table 2.

EQUIVALENTS OF BRITISH IMPERIAL AND METRIC WEIGHTS AND MEASURES.

(4) IMPERIAL TO METRIC.

	LINEAR MEASURE.					MEASURE OF CAPACITY.			
	Inches to centimetres.	Feet to metres.	Yards to metres.	Miles to kilometres.		Quarts to litres.	Gallons to litres.	Bushels to dekalitres.	Quarters to hectolitres.
1	2.539998	0.30480	0.91440	1.60934	1	1.13649	4.54596	3.63677	2.90942
2	5.079996	0.60960	1.82880	3.21869	2	2.27298	9.09193	7.27354	5.81883
3	7.619993	0.91440	2.74320	4.82803	3	3.40947	13.63789	10.91031	8.72825
4	10.159991	1.21920	3.65760	6.43737	4	4.54596	18.18385	14.54708	11.63767
5	12.699989	1.52400	4.57200	8.04671	5	5.68245	22.72982	18.18385	14.54708
6	15.239987	1.82880	5.48640	9.65606	6	6.81894	27.27578	21.82062	17.45650
7	17.779984	2.13360	6.40080	11.26540	7	7.95544	31.82174	25.45739	20.36591
8	20.319981	2.43840	7.31520	12.87474	8	9.09193	36.36770	29.09416	23.27533
9	22.859979	2.74320	8.22960	14.48408	9	10.22842	40.91367	32.73093	26.18475

	SQUARE MEASURE.					WEIGHT (Avoirdupois).			
	Square inches to square centimetres.	Square feet to square decimetres.	Square yards to square metres.	Acres to hectares.		Grains to milligrammes.	Ounces to grammes.	Pounds to kilogrammes.	Hundredweights to quintals.
1	6.45159	9.29029	0.83613	0.40468	1	64.79892	28.34953	0.45359	0.50802
2	12.90318	18.58058	1.67225	0.80937	2	129.59784	56.69905	0.90719	1.01605
3	19.35477	27.87086	2.50838	1.21405	3	194.39676	85.04858	1.36078	1.52407
4	25.80636	37.16115	3.34450	1.61874	4	259.19568	113.39811	1.81437	2.03209
5	32.25794	46.45144	4.18063	2.02342	5	323.99459	141.74763	2.26796	2.54012
6	38.70953	55.74173	5.01676	2.42811	6	388.79351	170.09716	2.72156	3.04814
7	45.16112	65.03202	5.85288	2.83279	7	453.59243	198.44669	3.17515	3.55617
8	51.61271	74.32230	6.68901	3.23748	8	518.39135	226.79622	3.62874	4.06419
9	58.06430	83.61259	7.52513	3.64216	9	583.19027	255.14574	4.08233	4.57221

	CUBIC MEASURE.			Apothecaries' Measure.		Avoirdupois (*cont.*).	Troy Weight.		Apothecaries' Weight.
	Cubic inches to cubic centimetres.	Cubic feet to cubic metres.	Cubic yards to cubic metres.	Fluid drachms to cubic centimetres.		Tons to milliers or tonnes.	Ounces to grammes.	Pennyweights to grammes.	Scruples to grammes.
1	16.38702	0.02832	0.76455	3.55153	1	1.01605	31.10348	1.55517	1.29598
2	32.77404	0.05663	1.52911	7.10307	2	2.03210	62.20696	3.11035	2.59196
3	49.16106	0.08495	2.29366	10.65460	3	3.04814	93.31044	4.66552	3.88794
4	65.54809	0.11327	3.05821	14.20614	4	4.06419	124.41392	6.22070	5.18391
5	81.93511	0.14158	3.82276	17.75767	5	5.08024	155.51741	7.77587	6.47989
6	98.32213	0.16990	4.58732	21.30920	6	6.09629	186.62089	9.33104	7.77587
7	114.70915	0.19822	5.35187	24.86074	7	7.11233	217.72417	10.88622	9.07185
8	131.09617	0.22653	6.11642	28.41227	8	8.12838	248.82785	12.44139	10.36783
9	147.48319	0.25485	6.88098	31.96381	9	9.14443	279.93133	13.99657	11.66381

TABLES FOR CONVERTING U. S. WEIGHTS AND MEASURES.*

(1) CUSTOMARY TO METRIC.

LINEAR.

	Inches to millimetres.	Feet to metres.	Yards to metres.	Miles to kilometres.
1	25.4001	0.304801	0.914402	1.60935
2	50.8001	0.609601	1.828804	3.21869
3	76.2002	0.914402	2.743205	4.82804
4	101.6002	1.219202	3.657607	6.43739
5	127.0003	1.524003	4.572009	8.04674
6	152.4003	1.828804	5.486411	9.65608
7	177.3004	2.133604	6.400813	11.26543
8	203.2004	2.438405	7.315215	12.87478
9	228.6005	2.743205	8.229616	14.48412

CAPACITY.

	Fluid drams to millimetres or cubic centimetres.	Fluid ounces to millilitres.	Quarts to litres.	Gallons to litres.
1	3.70	29.57	0.94636	3.78543
2	7.39	59.15	1.89272	7.57087
3	11.09	88.72	2.83908	11.35630
4	14.79	118.29	3.78543	15.14174
5	18.48	147.87	4.73179	18.92717
6	22.18	177.44	5.67815	22.71261
7	25.88	207.02	6.62451	26.49804
8	29.57	236.59	7.57087	30.28348
9	33.27	266.16	8.51723	34.06891

SQUARE.

	Square inches to square centimetres.	Square feet to square decimetres.	Square yards to square metres.	Acres to hectares.
1	6.452	9.290	0.836	0.4047
2	12.903	18.581	1.672	0.8094
3	19.355	27.871	2.508	1.2141
4	25.807	37.161	3.344	1.6187
5	32.258	46.452	4.181	2.0234
6	38.710	55.742	5.017	2.4281
7	45.161	65.032	5.853	2.8328
8	51.613	74.323	6.689	3.2375
9	58.065	83.613	7.525	3.6422

WEIGHT.

	Grains to milligrammes.	Avoirdupois ounces to grammes.	Avoirdupois pounds to kilogrammes.	Troy ounces to grammes.
1	64.7989	28.3495	0.45359	31.10348
2	129.5978	56.6991	0.90719	62.20696
3	194.3968	85.0486	1.36078	93.31044
4	259.1957	113.3981	1.81437	124.41392
5	323.9946	141.7476	2.26796	155.51740
6	388.7935	170.0972	2.72156	186.62088
7	453.5924	198.4467	3.17515	217.72437
8	518.3914	226.7962	3.62874	248.82785
9	583.1903	255.1457	4.08233	279.93133

CUBIC.

	Cubic inches to cubic centimetres.	Cubic feet to cubic metres.	Cubic yards to cubic metres.	Bushels to hectolitres.
1	16.387	0.02832	0.765	0.35239
2	32.774	0.05663	1.529	0.70479
3	49.161	0.08495	2.294	1.05718
4	65.549	0.11327	3.058	1.40957
5	81.936	0.14158	3.823	1.76196
6	98.323	0.16990	4.587	2.11436
7	114.710	0.19822	5.352	2.46675
8	131.097	0.22654	6.116	2.81914
9	147.484	0.25485	6.881	3.17154

1 Gunter's chain	=	20.1168	metres.
1 sq. statute mile	=	259.000	hectares.
1 fathom	=	1.829	metres.
1 nautical mile	=	1853.25	metres.
1 foot	=	0.304801	metre.
1 avoir. pound	=	453.5924277	gramme.
15432.35639 grains	=	1.000	kilogramme.

The only authorized material standard of customary length is the Troughton scale belonging to the United States Office of Standard Weights and Measures, whose length at 59°.62 Fahr. conforms to the British standard. The yard in use in the United States is therefore equal to the British yard.

The only authorized material standard of customary weight is the Troy pound of the Mint. It is of brass of unknown density, and therefore not suitable for a standard of mass. It was derived from the British standard Troy pound of 1758 by direct comparison. The British Avoirdupois pound was also derived from the latter, and contains 7,000 grains Troy.

The grain Troy is therefore the same as the grain Avoirdupois, and the pound Avoirdupois in use in the United States is equal to the British pound Avoirdupois.

The British gallon = 4.54346 litres.
The British bushel = 36.3477 litres.

The length of the nautical mile given above and adopted by the U. S. Coast and Geodetic Survey many years ago, is defined as that of a minute of arc of a great circle of a sphere whose surface equals that of the earth (Clarke's Spheroid of 1866).

* Quoted from sheets issued by the United States Office of Standard Weights and Measures.

TABLE 3.

TABLES FOR CONVERTING U. S. WEIGHTS AND MEASURES.

(2) METRIC TO CUSTOMARY.

LINEAR.

	Metres to inches.	Metres to feet.	Metres to yards.	Kilometres to miles.
1	39.3700	3.28083	1.093611	0.62137
2	78.7400	6.56167	2.187222	1.24274
3	118.1100	9.84250	3.280833	1.86411
4	157.4800	13.12333	4.374444	2.48548
5	196.8500	16.40417	5.468056	3.10685
6	236.2200	19.68500	6.561667	3.72822
7	275.5900	22.96583	7.655278	4.34959
8	314.9600	26.24667	8.748889	4.97096
9	354.3300	29.52750	9.842500	5.59233

CAPACITY.

•	Millilitres or cubic centimetres to fluid drams.	Centilitres to fluid ounces.	Litres to quarts.	Decalitres to gallons.	Hectolitres to bushels.
1	0.27	0.338	1.0567	2.6417	2.8377
2	0.54	0.676	2.1134	5.2834	5.6755
3	0.81	1.014	3.1700	7.9251	8.5132
4	1.08	1.353	4.2267	10.5668	11.3510
5	1.35	1.691	5.2834	13.2085	14.1887
6	1.62	2.029	6.3401	15.8502	17.0265
7	1.89	2.367	7.3968	18.4919	19.8642
8	2.16	2.705	8.4535	21.1336	22.7019
9	2.43	3.043	9.5101	23.7753	25.5397

SQUARE.

	Square centimetres to square inches.	Square metres to square feet.	Square metres to square yards.	Hectares to acres.
1	0.1550	10.764	1.196	2.471
2	0.3100	21.528	2.392	4.942
3	0.4650	32.292	3.588	7.413
4	0.6200	43.055	4.784	9.884
5	0.7750	53.819	5.980	12.355
6	0.9300	64.583	7.176	14.826
7	1.0850	75.347	8.372	17.297
8	1.2400	86.111	9.568	19.768
9	1.3950	96.875	10.764	22.239

WEIGHT.

	Milligrammes to grains.	Kilogrammes to grains.	Hectogrammes to ounces avoirdupois.	Kilogrammes to pounds avoirdupois.
1	0.01543	15432.36	3.5274	2.20462
2	0.03086	30864.71	7.0548	4.40924
3	0.04630	46297.07	10.5822	6.61387
4	0.06173	61729.43	14.1096	8.81849
5	0.07716	77161.78	17.6370	11.02311
6	0.09259	92594.14	21.1644	13.22773
7	0.10803	108026.49	24.6918	15.43236
8	0.12346	123458.85	28.2192	17.63698
9	0.13889	138891.21	31.7466	19.84160

CUBIC.

	Cubic centimetres to cubic inches.	Cubic decimetres to cubic inches.	Cubic metres to cubic feet.	Cubic metres to cubic yards.
1	0.0610	61.023	35.314	1.308
2	0.1220	122.047	70.629	2.616
3	0.1831	183.070	105.943	3.924
4	0.2441	244.094	141.258	5.232
5	0.3051	305.117	176.572	6.540
6	0.3661	366.140	211.887	7.848
7	0.4272	427.164	247.201	9.156
8	0.4882	488.187	282.516	10.464
9	0.5492	549.210	317.830	11.771

WEIGHT.

	Quintals to pounds av.	Milliers or tonnes to pounds av.	Kilogrammes to ounces Troy.
1	220.46	2204.6	32.1507
2	440.92	4409.2	64.3015
3	661.39	6613.9	96.4522
4	881.85	8818.5	128.6030
5	1102.31	11023.1	160.7537
6	1322.77	13227.7	192.9044
7	1543.24	15432.4	225.0552
8	1763.70	17637.0	257.2059
9	1984.16	19841.6	289.3567

By the concurrent action of the principal governments of the world an International Bureau of Weights and Measures has been established near Paris. Under the direction of the International Committee, two ingots were cast of pure platinum-iridium in the proportion of 9 parts of the former to 1 of the latter metal. From one of these a certain number of kilogrammes were prepared, from the other a definite number of metre bars. These standards of weight and length were intercompared, without preference, and certain ones were selected as International prototype standards. The others were distributed by lot, in September, 1889, to the different governments, and are called National prototype standards. Those apportioned to the United States were received in 1890, and are kept in the Office of Standard Weights and Measures in Washington, D. C.

The metric system was legalized in the United States in 1866.

The International Standard Metre is derived from the Mètre des Archives, and its length is defined by the distance between two lines at 0° Centigrade, on a platinum-iridium bar deposited at the International Bureau of Weights and Measures.

The International Standard Kilogramme is a mass of platinum-iridium deposited at the same place, and its weight in vacuo is the same as that of the Kilogramme des Archives.

The litre is equal to a cubic decimetre, and it is measured by the quantity of distilled water which, at its maximum density, will counterpoise the standard kilogramme in a vacuum, the volume of such a quantity of water being, as nearly as has been ascertained, equal to a cubic decimetre.

TABLE 4. — Conversion Factors for Expression of Lengths.

Dimensions = L.

Statute mile.		Nautical mile.		Yard.		Foot.		Inch.		Centimetre.*	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	8.68382×10^{-1}	$\bar{1}.938711$	1.76000×10^{3}	3.245513	5.28000×10^{3}	3.722634	6.33600×10^{4}	4.801815	1.60935×10^{5}	5.206650
1.15157	0.061289	1	0	2.02676×10^{3}	3.306802	6.08027×10^{3}	3.783923	7.29632×10^{4}	4.863104	1.85327×10^{5}	5.267939
5.68182×10^{-4}	$\bar{4}.754487$	4.93399×10^{-4}	$\bar{4}.693198$	1	0	3.00000	0.477121	3.60000×10	1.556302	9.14400×10	1.961137
1.89394×10^{-4}	$\bar{4}.277366$	1.64466×10^{-4}	$\bar{4}.216077$	3.33333×10^{-1}	$\bar{1}.522879$	1	0	1.20000×10	1.079181	3.04801×10	1.484016
1.57828×10^{-5}	$\bar{5}.198185$	1.37055×10^{-5}	$\bar{5}.136896$	2.77778×10^{-2}	$\bar{2}.443697$	8.33333×10^{-2}	$\bar{2}.920819$	1	0	2.54000	0.404835
6.21370×10^{-6}	$\bar{6}.793350$	5.39587×10^{-6}	$\bar{6}.732061$	1.09361×10^{-2}	$\bar{2}.038863$	3.28083×10^{-2}	$\bar{2}.515984$	3.93700×10^{-1}	$\bar{1}.595165$	1	0

* In accordance with the United States Standards the metre is taken as = 39.37 inches.

TABLE 5. — Conversion Factors for Expression of Areas.

Dimensions = L^2.

Square mile.		Square yard.		Square foot.		Square inch.		Square centimetre.		Circular mil.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	3.09760×10^{6}	6.491025	2.78784×10^{7}	7.445268	4.01449×10^{9}	9.603630	2.59000×10^{10}	10.413299	5.11141×10^{15}	15.708540
3.22831×10^{-7}	$\bar{7}.508975$	1	0	9.00000	0.954242	1.29600×10^{3}	3.112605	8.36127×10^{3}	3.922274	1.65012×10^{9}	9.217515
3.58701×10^{-8}	$\bar{8}.554732$	1.11111×10^{-1}	$\bar{1}.045757$	1	0	1.44000×10^{2}	2.158362	9.29030×10^{2}	2.968032	1.82925×10^{8}	8.262272
2.49098×10^{-10}	$\overline{10}.396370$	7.71605×10^{-4}	$\bar{4}.887395$	6.94444×10^{-3}	$\bar{3}.841637$	1	0	6.45163	0.809669	1.27324×10^{6}	6.104910
3.86101×10^{-11}	$\overline{11}.586700$	1.19598×10^{-4}	$\bar{4}.077726$	1.07639×10^{-3}	$\bar{3}.031968$	1.55000×10^{-1}	$\bar{1}.190331$	1	0	1.97352×10^{5}	5.295241
1.95641×10^{-16}	$\overline{16}.291460$	6.06017×10^{-10}	$\overline{10}.782485$	5.46673×10^{-9}	$\bar{9}.737727$	7.85398×10^{-7}	$\bar{7}.895090$	5.06709×10^{-6}	$\bar{6}.704759$	1	0

CONVERSION FACTORS.

TABLE 6. — Conversion Factors for Expression of Volumes.

Dimensions = L^3.

Cubic mile.		Cubic yard.		Cubic foot.		Cubic inch.		Cubic centimetre.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	**0**	5.45178×10^{9}	9.736538	1.47198×10^{11}	11.167902	2.54358×10^{14}	14.405445	4.16825×10^{15}	15.619948
1.83426×10^{-10}	$\overline{10}.263462$	**1**	**0**	2.70000×10	1.431364	4.66560×10^{4}	4.668907	7.64555×10^{5}	5.883410
6.79357×10^{-12}	$\overline{12}.832098$	3.70370×10^{-2}	$\bar{2}.568636$	**1**	**0**	1.72800×10^{3}	3.237544	2.83168×10^{4}	4.452046
3.94071×10^{-15}	$\overline{15}.594555$	2.14334×10^{-5}	$\bar{5}.331092$	5.78704×10^{-4}	$\bar{4}.762456$	**1**	**0**	1.63871×10	1.214502
2.40796×10^{-16}	$\overline{16}.380052$	1.30795×10^{-6}	$\bar{6}.116590$	3.53147×10^{-5}	5.547954	6.10236×10^{-2}	$\bar{2}.785498$	**1**	**0**

TABLE 7. — Conversion Factors for Expression of Capacities.

Dimensions = L^3.

Cubic foot.		Cubic inch.		United States gallon.		British gallon.		Litres.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	**0**	1.72800×10^{3}	3.237544	7.48052	0.873932	6.22785	0.794339	2.83168×10	1.452046
5.78704×10^{-4}	$\bar{4}.762456$	**1**	**0**	4.32900×10^{-3}	$\bar{3}.636388$	3.60408×10^{-3}	$\bar{3}.556795$	1.63872×10^{-2}	$\bar{2}.214502$
1.33681×10^{-1}	$\bar{1}.126068$	2.31000×10^{2}	2.363612	**1**	**0**	8.32544×10^{-1}	$\bar{1}.920407$	3.78542	0.578114
1.60569×10^{-1}	$\bar{1}.205661$	*2.77463×10^{2}	2.443205	1.20114	0.079593	**1**	**0**	4.54682	0.657707
3.53147×10^{-2}	$\bar{2}.547954$	6.10236×10	1.785498	2.64171×10^{-1}	$\bar{1}.421886$	2.19934×10^{-1}	$\bar{1}.342292$	**1**	**0**

* Founded on weight of one cubic inch of water at 62° F. = 252.286 grains, and one British gallon = 10 pounds Avoirdupois.

CONVERSION FACTORS.

TABLE 8. — Conversion Factors for Expression of Masses.*

Dimensions = M.

British or Long Ton. (2240 lbs.)		U. S. or Short Ton. (2000 lbs.)		Pound.		Grain.		Gramme.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	1.12000	0.049218	2.24000×10^3	3.350248	1.56800×10^7	7.195346	1.01605×10^6	6.006914
8.92857×10^{-1}	$\bar{1}.950782$	1	0	2.00000×10^3	3.301030	1.40000×10^7	7.146128	9.07186×10^5	5.957696
4.46429×10^{-4}	$\bar{4}.649752$	5.00000×10^{-4}	$\bar{4}.698970$	1	0	7.00000×10^3	3.845098	4.53593×10^2	2.656666
6.37755×10^{-8}	$\bar{8}.804654$	7.14286×10^{-8}	$\bar{8}.853872$	1.42857×10^{-4}	$\bar{4}.154902$	1	0	6.47989×10^{-2}	$\bar{2}.811568$
9.84205×10^{-7}	$\bar{7}.993086$	1.10231×10^{-6}	$\bar{6}.042304$	2.20462×10^{-3}	$\bar{3}.343334$	1.54324×10	1.188432	1	0

* The French tonne = 1000 kilogrammes = 10^6 grammes. The troy pound = 5760 grains. The troy ounce = 480 grains. The avoirdupois ounce = 437.5 grains. Troy weight is used for gold, silver, and jewels, except diamonds and pearls, for which the grain is 0.8 troy grain. One carat = 3.2 troy grains.

TABLE 9. — Conversion Factors for Expression of Moments of Inertia.

Dimensions = ML^2.

Foot Pound Units.		Inch Pound Units.		Foot Grain Units.		Centimetre Gramme Units.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	1.44000×10^2	2.158362	7.00000×10^3	3.845098	4.21402×10^5	5.624698
6.94444×10^{-3}	$\bar{3}.841637$	1	0	4.86111×10	1.686735	2.92640×10^3	3.466336
1.42857×10^{-4}	$\bar{4}.154902$	2.05714×10^{-2}	$\bar{2}.313264$	1	0	6.02005×10	1.779600
2.37302×10^{-6}	$\bar{6}.375302$	3.41715×10^{-4}	$\bar{4}.533664$	1.66111×10^{-2}	$\bar{2}.220400$	1	0

CONVERSION FACTORS.

TABLE 10. — Conversion Factors for Expression of Angles.

Dimension = 1.

Radian.		Degree.		Hundredth of Circumference.	
No.	Log.	No.	Log.	No.	Log.
1	0	5.72958×10	1.758123	1.59155×10	1.201819
1.74533×10^{-2}	$\bar{2}.241878$	1	0	2.77778×10^{-1}	$\bar{1}.443697$
6.28319×10^{-2}	$\bar{2}.798180$	3.60000	0.556302	1	0

TABLE 11. — Conversion Factors for Expression of Intervals of Time.

Dimensions = T.

Sidereal Day.*		Mean Solar Day.		Mean Solar Hour.		Mean Solar Minute.		Mean Solar Second.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	9.97270×10^{-1}	$\bar{1}.998813$	2.39345×10	1.379024	1.43607×10^{3}	3.157175	8.61641×10^{4}	4.935326
1.00274	0.001187	1	0	2.40000×10	1.380211	1.44000×10^{3}	3.158362	8.64000×10^{4}	4.936514
4.17807×10^{-2}	$\bar{2}.620976$	4.16667×10^{-2}	$\bar{2}.619789$	1	0	6.00000×10	1.778151	3.60000×10^{3}	3.556302
6.96346×10^{-4}	$\bar{4}.842825$	6.94444×10^{-4}	$\bar{4}.841637$	1.66667×10^{-2}	$\bar{2}.221849$	1	0	6.00000×10	1.778151
1.16058×10^{-5}	$\bar{5}.064674$	1.15741×10^{-5}	$\bar{5}.063486$	2.77778×10^{-4}	$\bar{4}.443697$	1.66667×10^{-2}	$\bar{2}.221849$	1	0

* The sidereal year = 365.2563578 mean solar days.

CONVERSION FACTORS.

TABLE 12. — Conversion Factors for Expression of Velocities.

Dimensions = L/T.

Miles per hour.		Feet per second.		Kilometres per hour.		Metres per minute.		Centimetres per second.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	1.46667	0.166331	1.60934	0.206650	2.68224×10	1.428499	4.47040×10	1.650347
6.81828×10^{-1}	$\bar{1}.833669$	1	0	1.09727	0.040318	1.82880×10	1.262167	3.04801×10	1.484016
6.21371×10^{-1}	$\bar{1}.793350$	9.11344×10^{-1}	$\bar{1}.959681$	1	0	1.66667×10	1.221849	2.77778×10	1.443697
3.72821×10^{-2}	$\bar{2}.571501$	5.46807×10^{-2}	$\bar{2}.737833$	6.00000×10^{-2}	$\bar{2}.778151$	1	0	1.66667	0.221849
2.23694×10^{-2}	$\bar{2}.349653$	3.28084×10^{-2}	$\bar{2}.515984$	3.60000×10^{-2}	$\bar{2}.556302$	6.00000×10^{-1}	$\bar{1}.778151$	1	0

TABLE 13. — Conversion Factors for Expression of Angular Velocities (angle/time).

Dimensions = 1/T.

Revolutions per hour.		Revolutions per minute.		Revolutions per second.		Radians per minute.		Radians per second.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	1.66667×10^{-2}	$\bar{2}.221849$	2.77778×10^{-4}	$\bar{4}.443697$	1.04720×10^{-1}	$\bar{1}.020028$	1.74533×10^{-3}	$\bar{3}.241877$
6.00000×10	1.778151	1	0	1.66667×10^{-2}	$\bar{2}.221849$	6.28319	0.798180	1.04720×10^{-1}	$\bar{1}.020028$
3.60000×10^{3}	3.556303	6.00000×10	1.778151	1	0	3.76998×10^{3}	3.576331	6.28319	0.798180
9.54944	0.979972	1.59155×10^{-1}	$\bar{1}.201820$	2.65258×10^{-3}	$\bar{3}.423669$	1	0	1.66667×10^{-2}	$\bar{2}.221849$
5.72958×10^{2}	2.758123	9.54944	0.979972	1.59155×10^{-1}	$\bar{1}.201820$	6.00000×10	1.778151	1	0

CONVERSION FACTORS.

TABLE 14. — Conversion Factors for Expression of Momentum.

Dimensions = ML/T.

Mile Ton Hour Units. (One ton = 2000 lbs.)		Foot Pound Second Units.		Foot Grain Second Units.		Metre Kilogramme Second Units.		Centimetre Gramme Second Units.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	2.93333×10^3	3.467361	2.05333×10^7	7.312459	4.05549×10^2	2.608044	4.05549×10^7	7.608044
3.40909×10^{-4}	$\bar{4}.532639$	1	0	7.00000×10^3	3.845098	1.38255×10^{-1}	$\bar{1}.140682$	1.38255×10^4	4.140682
4.87013×10^{-8}	$\bar{8}.687541$	1.42857×10^{-4}	$\bar{4}.154902$	1	0	1.97508×10^{-5}	$\bar{5}.295584$	1.97508	0.295584
2.46580×10^{-3}	$\bar{3}.391956$	7.23300	0.859318	5.06309×10^4	4.704416	1	0	1.00000×10^5	5.000000
2.46580×10^{-8}	$\bar{8}.391956$	7.23300×10^{-5}	$\bar{5}.859318$	5.06309×10^{-1}	$\bar{1}.704416$	1.00000×10^{-5}	$\bar{5}.000000$	1	0

TABLE 15. — Conversion Factors for Expression of Moments of Momentum.

Dimensions = ML²/T.

Foot Pound Second Units.		Inch Pound Second Units.		Foot Grain Second Units.		Metre Kilogramme Second Units.		Centimetre Gramme Second Units.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	1.44000×10^2	2.158362	7.00000×10^3	3.845098	4.21402×10^{-2}	$\bar{2}.624698$	4.21402×10^5	5.624698
6.94444×10^{-3}	$\bar{3}.841637$	1	0	4.86112×10	1.686736	2.92640×10^{-4}	$\bar{4}.466336$	2.92640×10^3	3.466336
1.42857×10^{-4}	$\bar{4}.154902$	2.05714×10^{-2}	$\bar{2}.313263$	1	0	6.02002×10^{-6}	$\bar{6}.779600$	6.02002×10	1.779600
2.37302×10	1.375302	3.41716×10^3	3.533664	1.66112×10^5	5.220400	1	0	1.00000×10^7	7.000000
2.37302×10^{-6}	$\bar{6}.375302$	3.41716×10^{-4}	$\bar{4}.533664$	1.66112×10^{-2}	$\bar{2}.220400$	1.00000×10^{-7}	$\bar{7}.000000$	1	0

TABLE 16. — Conversion Factors for Expression of Force or Time Rate of Change of Momentum.

Dimensions = ML/T^2.

Dynes. (Cm. Gr. Sec. Units.)		Millimetre Milligramme Second Units.		Poundals. (Foot Pound Second Units.)		Foot Grain Second Units.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	1.00000×10^4	4.000000	7.23300×10^{-5}	$\bar{5}.859318$	5.06310×10^{-1}	$\bar{1}.704416$
1.00000×10^{-4}	$\bar{4}.000000$	1	0	7.23300×10^{-9}	$\bar{9}.859318$	5.06310×10^{-5}	$\bar{5}.704416$
1.38255×10^4	4.140682	1.38255×10^8	8.140682	1	0	7.00000×10^3	3.845098
1.97507	0.295584	1.97507×10^4	4.295584	1.42854×10^{-4}	$\bar{4}.154902$	1	0

TABLE 17. — Conversion Factors for Expression of Linear Accelerations.

Dimensions = L/TT'.

Miles {per hour, per sec. / per sec, per hour.		Miles {per hour, per min. / per min., per hour.		Feet per sec., per sec.		Kilom. {per hour, per sec. / per sec., per hour.		Kilom. {per hour, per min. / per min., per hour.		Centimetres per sec., per sec.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	6.00000×10	1.778151	1.46667	0.166331	1.60935	0.206650	9.65606×10	1.984801	4.47040×10	1.650347
1.66667×10^{-2}	$\bar{2}.221849$	1	0	2.44444×10^{-2}	$\bar{2}.388180$	2.68223×10^{-2}	$\bar{2}.428498$	1.60934	0.206650	7.45067×10^{-1}	$\bar{1}.872196$
6.81818×10^{-1}	$\bar{1}.833669$	4.09091×10	1.611820	1	0	1.09728	0.040318	6.58368×10	1.818470	3.04801×10	1.484016
6.21371×10^{-1}	$\bar{1}.793350$	3.72824×10	1.571502	9.11344×10^{-1}	$\bar{1}.959681$	1	0	6.00000×10	1.778151	2.77778×10	1.443697
1.03562×10^{-2}	$\bar{2}.015199$	6.21371×10^{-1}	$\bar{1}.793350$	1.51891×10^{-2}	$\bar{2}.181530$	1.66667×10^{-2}	$\bar{2}.221849$	1	0	4.62963×10^{-1}	$\bar{1}.665546$
2.23694×10^{-2}	$\bar{2}.349653$	1.34216	0.127804	3.28083×10^{-2}	$\bar{2}.515984$	3.60000×10^{-2}	$\bar{2}.556302$	2.16000	0.334454	1	0

CONVERSION FACTORS.

TABLE 18.—Conversion Factors for Expression of Angular Accelerations.

Dimensions = ANGLE/TT′.

Rev. {per min., per sec. / per sec., per min.} No.	Log.	Revolutions per min., per min. No.	Log.	Revolutions per sec., per sec. No.	Log.	Radians {per min., per sec. / per sec., per min.} No.	Log.	Radians per min., per min. No.	Log.	Radians per sec., per sec. No.	Log.
1	0	6.00000 × 10	1.778151	1.66667 × 10^{-2}	$\bar{2}$.221849	6.28319	0.798180	3.76991 × 10^{2}	2.576331	1.04720 × 10^{-1}	$\bar{1}$.020029
1.66667 × 10^{-2}	$\bar{2}$.221849	1	0	2.77778 × 10^{-4}	$\bar{4}$.443697	1.04720 × 10^{-1}	$\bar{1}$.020028	6.28319	0.798180	1.74533 × 10^{-3}	$\bar{3}$.241877
6.00000 × 10	1.778151	3.60000 × 10^{3}	3.556303	1	0	3.76990 × 10^{2}	2.576331	2.26195 × 10^{4}	4.354482	6.28319	0.798180
1.59155 × 10^{-1}	$\bar{1}$.201820	9.54930	0.979971	2.65258 × 10^{-3}	$\bar{3}$.423669	1	0	6.00000 × 10	1.778151	1.66667 × 10^{-2}	$\bar{2}$.221849
2.65258 × 10^{-3}	$\bar{3}$.423669	1.59155 × 10^{-1}	$\bar{1}$.201820	4.42097 × 10^{-5}	$\bar{5}$.645517	1.66667 × 10^{-2}	$\bar{2}$.221849	1	0	2.77778 × 10^{-4}	$\bar{4}$.443697
9.54930	0.979971	5.72958 × 10^{2}	2.758123	1.59155 × 10^{-1}	$\bar{1}$.201820	6.00000 × 10	1.778151	3.60000 × 10^{3}	3.556303	1	0

TABLE 19.—Conversion Factors for Expression of Linear and Angular Accelerations, when the Time Unit only changes.

Dimensions = $1/T^2$

Mean Solar Day. No.	Log.	Mean Solar Hour. No.	Log.	Mean Solar Minute. No.	Log.	Mean Solar Second. No.	Log.	Sidereal Day. No.	Log.	Sidereal Second. No.	Log.
1	0	1.73611 × 10^{-3}	$\bar{3}$.239577	4.82253 × 10^{-7}	$\bar{7}$.683275	1.33961 × 10^{-10}	$\overline{10}$.126972	9.94547 × 10^{-1}	$\bar{1}$.997625	1.33229 × 10^{-10}	$\overline{10}$.124598
5.76000 × 10^{2}	2.760422	1	0	2.77778 × 10^{-4}	4.443697	7.71605 × 10^{-8}	$\bar{8}$.887395	5.72859 × 10^{2}	2.758048	7.67397 × 10^{-8}	$\bar{8}$.885020
2.07360 × 10^{6}	6.316725	3.60000 × 10^{3}	3.556302	1	0	2.77778 × 10^{-4}	$\bar{4}$.443697	2.06229 × 10^{6}	6.314350	2.76263 × 10^{-4}	$\bar{4}$.441323
7.46496 × 10^{9}	9.873027	1.29600 × 10^{7}	7.112605	3.60000 × 10^{3}	3.556302	1	0	7.42425 × 10^{9}	9.870653	9.94547 × 10^{-1}	$\bar{1}$.997625
1.00548	0.002375	1.74563 × 10^{-3}	$\bar{3}$.241952	4.84897 × 10^{-7}	$\bar{7}$.685650	1.34694 × 10^{-10}	$\overline{10}$.129347	1	0	1.33961 × 10^{-10}	$\overline{10}$.126972
7.50589 × 10^{9}	9.875402	1.30311 × 10^{7}	7.114980	3.61974 × 10^{3}	3.558677	1.00548	0.002375	7.46496 × 10^{9}	9.873027	1	0

CONVERSION FACTORS.

TABLE 20. — Conversion Factors for Expression of Stress or Force per Unit Area. (Gravitation Measure.)

Dimensions = M/LT^2.

Tons per square inch. One ton = 2240 lbs.		Pounds per square foot.		Pounds per square inch.		Grammes per square centimetre.		Inches of mercury at 0° Cent.		Centimetres of mercury at 0° Cent.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	3.22560×10^5	5.508610	2.24000×10^3	3.350248	1.57487×10^5	5.197245	4.56050×10^3	3.659013	1.15837×10^4	4.063847
3.10019×10^{-6}	$\bar{6}.491389$	1	0	6.94444×10^{-3}	$\bar{3}.841637$	4.88241×10^{-1}	$\bar{1}.688634$	1.41385×10^{-2}	$\bar{2}.150402$	3.59117×10^{-2}	$\bar{2}.555236$
4.46429×10^{-4}	$\bar{4}.649752$	1.44000×10^2	2.158362	1	0	7.03067×10	1.846997	2.03594	0.308765	5.17129	0.713599
6.34973×10^{-6}	$\bar{6}.802755$	2.04817	0.311365	1.42234×10^{-2}	$\bar{2}.153003$	1	0	2.89579×10^{-2}	$\bar{2}.461768$	7.35532×10^{-3}	$\bar{3}.866602$
2.19274×10^{-4}	$\bar{4}.340987$	7.07290×10	1.849598	4.91174×10^{-1}	$\bar{1}.691235$	3.45328×10	1.538232	1	0	2.57000	0.404834
8.63283×10^{-5}	$\bar{5}.936153$	2.78461×10	1.444764	1.93376×10^{-1}	$\bar{1}.286401$	1.35956×10	1.133398	3.93701×10^{-1}	$\bar{1}.595166$	1	0

TABLE 21. — Conversion Factors for Expression of Power, Rate of Working, or Activity. (Gravitation Measure.)

Dimensions = ML^2/T^3.

Horse power.		Foot Pounds per second.		Foot Pounds per minute.		Force de cheval.*		Kilogramme Metres per minute.		Gramme Centimetres per second.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	5.50000×10^2	2.740363	3.30000×10^4	4.518514	1.01387	0.005984	4.56242×10^3	3.659196	7.60403×10^6	6.881045
1.81818×10^{-3}	$\bar{3}.259637$	1	0	6.00000×10	1.778151	1.84340×10^{-3}	$\bar{3}.265621$	8.29531	0.918833	1.38255×10^4	4.140682
3.03030×10^{-5}	$\bar{5}.481486$	1.66667×10^{-2}	$\bar{2}.221849$	1	0	3.07241×10^{-5}	$\bar{5}.487470$	1.38252×10^{-1}	$\bar{1}.140682$	2.30425×10^2	2.362531
9.86319×10^{-1}	$\bar{1}.994016$	5.42475×10^2	2.734379	3.25485×10^4	4.512530	1	0	4.50000×10^3	3.653213	7.50000×10^6	6.875061
2.19182×10^{-4}	$\bar{4}.340804$	1.20550×10^{-1}	$\bar{1}.081166$	7.23327	0.859328	2.22222×10^{-4}	$\bar{4}.346787$	1	0	1.66667×10^3	3.221849
1.31509×10^{-7}	$\bar{7}.118955$	7.23300×10^{-5}	$\bar{5}.859319$	4.33990×10^{-3}	$\bar{3}.637479$	1.33333×10^{-7}	$\bar{7}.124939$	6.00000×10^{-4}	$\bar{4}.778151$	1	0

* One force de cheval = 75 kilogramme metres per second.

CONVERSION FACTORS.

TABLE 22. — Conversion Factors for Expression of Work or Energy. (Gravitation Measure.)

Dimensions = ML^2/T^2.

Foot Tons. (One ton = 2240 lbs.)		Foot Tons. (One ton = 2000 lbs.)		Foot Pounds.		Foot Grains.		Kilogramme Metres.		Gramme Centimetres.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	1.12000	0.049218	2.24000×10^3	3.350248	1.56800×10^7	7.195346	3.09691×10^2	2.490930	3.09691×10^7	7.490930
8.92857×10^{-1}	$\bar{1}.950782$	1	0	2.00000×10^3	3.301030	1.40000×10^7	7.146128	2.76510×10^2	2.441712	2.76510×10^7	7.441712
4.46429×10^{-4}	$\bar{4}.649752$	5.00000×10^{-4}	$\bar{4}.698970$	1	0	7.00000×10^3	3.845098	1.38255×10^{-1}	$\bar{1}.140682$	1.38255×10^4	4.140682
6.37755×10^{-8}	$\bar{8}.804654$	7.14285×10^{-8}	$\bar{8}.853872$	1.42854×10^{-4}	$\bar{4}.154902$	1	0	1.97507×10^{-6}	$\bar{5}.295584$	1.97507	0.295584
3.22902×10^{-3}	$\bar{3}.509070$	3.61650×10^{-3}	$\bar{3}.558288$	7.23300	0.859318	5.06310×10^4	4.704416	1	0	1.00000×10^5	5.000000
3.22902×10^{-8}	$\bar{8}.509070$	3.61650×10^{-8}	$\bar{8}.558288$	7.23300×10^{-5}	$\bar{5}.859318$	5.06310×10^{-1}	$\bar{1}.704416$	1.00000×10^{-5}	$\bar{5}.000000$	1	0

TABLE 23. — Conversion Factors for Expression of Film or Surface Tension. (Gravitation Measure.)

Dimensions = M/T^2.

Pounds per linear foot.		Pounds per linear inch.		Grains per linear inch.		Grammes per linear centimetre.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	8.33333×10^{-2}	$\bar{2}.920819$	5.83333×10^2	2.765917	1.48816×10	1.172650
1.20000×10	1.079181	1	0	7.00000×10^3	3.845098	1.78579×10^2	2.251832
1.71428×10^{-3}	$\bar{3}.234083$	1.42854×10^{-4}	$\bar{4}.154902$	1	0	2.55113×10^{-2}	$\bar{2}.406734$
6.71971×10^{-2}	2.827349	5.59976×10^{-3}	$\bar{3}.748168$	3.91983×10	1.593266	1	0

CONVERSION FACTORS.

TABLE 24. — Conversion Factors for Expression of Power, Rate of Working or Activity. (Absolute Measure.)

Dimensions = ML^2/T^3.

Foot Poundals per second.		Centimetre Dynes or Ergs per second.		Watts.		Horse power. ($g = 981$)		Force de cheval. ($g = 981$)	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	4.21403×10^5	5.624698	4.21403×10^{-2}	$\bar{2}.624698$	5.64917×10^{-5}	$\bar{5}.751985$	5.72755×10^{-5}	$\bar{5}.757969$
2.37302×10^{-6}	$\bar{6}.375302$	1	0	1.00000×10^{-7}	$\bar{7}.000000$	1.34056×10^{-10}	$\overline{10}.127287$	1.35916×10^{-10}	$\overline{10}.133271$
2.37302×10	1.375302	1.00000×10^7	7.000000	1	0	1.34056×10^{-3}	$\bar{3}.127287$	1.35916×10^{-3}	$\bar{3}.133271$
1.77013×10^4	4.248015	7.45956×10^9	9.872713	7.45956×10^2	2.872713	1	0	1.01387	0.005984
1.74595×10^4	4.242031	7.35750×10^9	9.866730	7.35750×10^2	2.866730	9.86319×10^{-1}	$\bar{1}.994016$	1	0

TABLE 25. — Conversion Factors for Expressing Work or Energy. (Absolute Measure.)

Dimensions = ML^2/T^2.

Foot Poundals.		Ergs or Centimetre Dynes.		Joules.		Foot Pounds. ($g = 32.18504$)		Gramme Centimetres.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	4.21403×10^5	5.624698	4.21403×10^{-2}	$\bar{2}.624698$	3.10704×10^{-2}	$\bar{2}.492347$	4.29565×10^2	2.633029
2.37302×10^{-6}	$\bar{6}.375302$	1	0	1.00000×10^{-7}	$\bar{7}.000000$	7.37308×10^{-8}	$\bar{8}.867649$	1.01937×10^{-3}	$\bar{3}.008331$
2.37302×10	1.375302	1.00000×10^7	7.000000	1	0	7.37308×10^{-1}	$\bar{1}.867649$	1.01937×10^4	4.008331
3.21850×10	1.507653	1.35629×10^7	7.132351	1.35629	0.132351	1	0	1.38255×10^4	4.140682
2.32794×10^{-3}	$\bar{3}.366971$	9.81000×10^2	2.991669	9.81000×10^{-5}	$\bar{5}.991669$	7.23299×10^{-5}	$\bar{5}.859318$	1	0

CONVERSION FACTORS.

TABLE 26. — Conversion Factors for Expression of Stress or Force per Unit of Area. (Absolute Measure.)

Dimensions = M / LT^2.

Poundals per square foot.		Poundals per square inch.		Dynes per square centimetre.		Megadynes per square metre.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	6.94444×10^{-3}	$\bar{3}.841638$	1.48816×10	1.172651	1.48816×10^{-1}	$\bar{1}.172651$
1.44000×10^{2}	2.158362	1	0	2.14295×10^{3}	3.331013	2.14295×10	1.331013
6.71971×10^{-2}	$\bar{2}.827349$	4.66646×10^{-4}	$\bar{4}.668987$	1	0	1.00000×10^{-2}	$\bar{2}.000000$
6.71971	0.827349	4.66646×10^{-2}	$\bar{2}.668987$	1.00000×10^{2}	2.000000	1	0

TABLE 27. — Conversion Factors for Expression of Film or Surface Tension. (Absolute Measure.)

Dimensions = M / T^2.

Poundals per linear inch.		Dynes per linear cm.		Grains per linear inch. ($g = 981$ cms. per sec., per sec)		Grammes per linear cm. ($g = 981$ cms. per sec., per sec.)	
No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	5.44312×10^{3}	3.735848	2.17490×10^{2}	2.337445	5.54854	0.744179
1.83723×10^{-4}	$\bar{4}.264152$	1	0	3.99573×10^{2}	2.601597	1.01937×10^{-3}	$\bar{3}.008331$
4.59786×10^{-3}	$\bar{3}.662556$	2.50267×10^{-1}	$\bar{1}.398403$	1	0	2.55114×10^{-2}	$\bar{2}.406734$
1.80228×10^{-1}	$\bar{1}.255821$	9.81000×10^{2}	2.991669	3.91981×10	1.593266	1	0

CONVERSION FACTORS.

TABLE 28. — Conversion Factors for Expression of Densities.

Dimensions = M / L^3.

Tons per cubic mile. 2000 pounds = 1 ton.		Pounds per cubic foot.		Pounds per cubic inch.		Grains per cubic inch.		Grammes per cubic centim.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	1.35872×10^{-8}	$\bar{8}.133128$	7.86293×10^{-12}	$\bar{12}.895584$	5.50405×10^{-8}	$\bar{8}.740683$	2.17644×10^{-10}	$\bar{10}.337748$
7.35990×10^{7}	7.866872	1	0	5.78704×10^{-4}	$\bar{4}.762456$	4.05093	0.607554	1.60184×10^{-2}	$\bar{2}.204620$
1.27179×10^{11}	11.104415	1.72800×10^{3}	3.237544	1	0	7.00000×10^{3}	3.845098	2.76799×10	1.442164
1.81685×10^{7}	7.259317	2.46857×10^{-1}	$\bar{1}.392446$	1.42857×10^{-4}	$\bar{4}.154902$	1	0	3.95428×10^{-3}	$\bar{3}.597066$
4.59466×10^{9}	9.662252	6.24281×10^{1}	1.795380	3.61274×10^{-2}	$\bar{2}.557836$	2.52891×10^{2}	2.402934	1	0

TABLE 29. — Conversion Factors for Expression of Specific Electrical Conductance.

Dimensions = $L / \mu T$.

Conductance of a Mile.* (d = 1 inch.)		Conductance of a Yard.* (d = one mil.)		Conductance of a Kilometre.* (d = 1 cm.)		Conductance of a Metre.* (d = 1 mm.)		Conductance of a Cubic Centimetre.*	
No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	1.76000×10^{-3}	$\bar{3}.245513$	2.49448×10^{-1}	$\bar{1}.396981$	2.49448	0.396981	3.17607×10^{4}	4.501891
5.68182×10^{2}	2.754487	1	0	1.41732×10^{2}	2.151368	1.41732×10^{3}	3.151468	1.80459×10^{7}	7.256378
4.00884	0.603019	7.05557×10^{-3}	$\bar{3}.848532$	1	0	1.00000×10	1.000000	1.27324×10^{5}	5.104910
4.00884×10^{-1}	$\bar{1}.603019$	7.05557×10^{-4}	$\bar{4}.848532$	1.00000×10^{-1}	$\bar{1}.000000$	1	0	1.27324×10^{4}	4.104910
3.14854×10^{-5}	$\bar{5}.498109$	5.54143×10^{-8}	$\bar{8}.743622$	7.85398×10^{-6}	$\bar{6}.895090$	7.85398×10^{-6}	$\bar{5}.895090$	1	0

* Taken as unit.

CONVERSION FACTORS.

TABLE 30. — Conversion Factors for Expression of Electrolytic Deposition.

Dimensions = M/T.

Grains per second.		Pounds per minute.		Grammes per second.		Kilogrammes per minute.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	8.57143×10^{-3}	$\bar{3}.933053$	6.47989×10^{-2}	$\bar{2}.811568$	3.88793×10^{-3}	$\bar{3}.589719$
1.16667×10^{2}	2.066947	1	0	7.55988	0.878515	4.53593×10^{-1}	$\bar{1}.656666$
1.54323×10	1.188432	1.32277×10^{-1}	$\bar{1}.121485$	1	0	6.00000×10^{-2}	$\bar{2}.778151$
2.57206×10^{2}	2.410281	2.20462	0.343334	1.66667×10	1.221849	1	0

TABLE 31. — Conversion Factors for Expression of Quantities of Heat.

Dimensions = MΘ.

Calorie. (Kilogramme degree C.)		Therm, or Small Calorie. (Gramme degree C.)		British Thermal Unit. (Pound degree F.)		(Pound degree C.)	
No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	1.00000×10^{3}	3.000000	3.96832	0.598607	2.20462	0.343334
1.00000×10^{-3}	$\bar{3}.000000$	1	0	3.96832×10^{-3}	$\bar{3}.598607$	2.20462×10^{-3}	$\bar{3}.343334$
2.51996×10^{-1}	$\bar{1}.401393$	2.51996×10^{2}	2.401393	1	0	5.56836×10^{-1}	$\bar{1}.745727$
4.53593×10^{-1}	$\bar{1}.656666$	4.53593×10^{2}	2.656666	1.79586	0.254273	1	0

CONVERSION FACTORS.

TABLE 32. — Conversion Factors for Expression of Temperatures.

Dimension = Θ.

Centigrade.		Fahrenheit.*		Réaumur.	
No.	Log.	No.	Log.	No.	Log.
1	0	1.80000	0.255272	8.00000×10^{-1}	$\bar{1}.903090$
5.55556×10^{-1}	$\bar{1}.744727$	1	0	4.44444×10^{-1}	$\bar{1}.647817$
1.25000	0.096910	2.25000	0.352182	1	0

* The zero of the Fahrenheit scale is 32° below the freezing point of water.

In many of the derived units for the measurement of physical quantities, the unit of time may be taken as constant, because it is seldom that any other unit than the second is used. This is the case, in particular, for the electric and magnetic units. Tables 33–37 below, giving the factors for the conversion of units depending on different dimensional equations in M and L from one set of fundamental units to another, will be found sufficient for almost all cases.

TABLE 33. — Electric Displacement, etc.

Dimensions = $M^{\frac{1}{2}}L^{-\frac{3}{2}}T^{n}$.

Foot Grain Second Units.		Metre Gramme Second Units.		Centimetre Gramme or Millimetre Milligramme Second Units.	
No.	Log.	No.	Log.	No.	Log.
1	0	1.51273	0.179760	1.51273×10^{-8}	$\bar{3}.179760$
6.61058×10^{-1}	$\bar{1}.820240$	1	0	1.00000×10^{-8}	$\bar{3}.000000$
6.61058×10^{2}	2.820240	1.00000×10^{8}	3.000000	1	0

CONVERSION FACTORS.

TABLE 34. — Surface Density of Magnetism, etc.

Dimensions = $M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}$.

Foot Grain Second Units.		Metre Gramme Second Units.		Centimetre Gramme Second Units.		Millimetre Milligramme Second Units.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	4.61079×10^{-1}	$\bar{1}.663776$	4.61079×10^{-2}	$\bar{2}.663776$	4.61079	0.663776
2.16882	0.336224	1	0	1.00000×10^{-1}	$\bar{1}.000000$	1.00000×10	1.000000
2.16882×10	1.336224	1.00000×10	1.000000	1	0	1.00000×10^{2}	2.000000
2.16882×10^{-1}	$\bar{1}.336224$	1.00000×10^{-1}	$\bar{1}.000000$	1.00000×10^{-2}	$\bar{2}.000000$	1	0

TABLE 35. — Intensity of Magnetization,* etc.

Dimensions = $M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}$.

Foot Grain Second Units.		Metre Gramme Second Units.		Centimetre Gramme Second Units.		Millimetre Milligramme Second Units.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	1.40538×10^{-1}	$\bar{1}.147792$	1.40538	0.147792	1.40538×10^{2}	2.147792
7.11554	0.852208	1	0	1.00000×10	1.000000	1.00000×10^{3}	3.000000
7.11554×10^{-1}	$\bar{1}.852208$	1.00000×10^{-1}	$\bar{1}.000000$	1	0	1.00000×10^{2}	2.000000
7.11554×10^{-3}	$\bar{3}.852208$	1.00000×10^{-3}	$\bar{3}.000000$	1.00000×10^{-2}	$\bar{2}.000000$	1	0

* In electrostatic units. For electromagnetic units take table 34.

CONVERSION FACTORS.

TABLE 36. — Electric Potential, etc.

Dimensions = $M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}$.

Foot Grain Second Units.		Metre Gramme Second Units.		Centimetre Gramme Second Units.		Millimetre Milligramme Second Units.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	4.28359×10^{-2}	$\bar{2}.631808$	4.28359×10	1.631808	4.28359×10^{4}	4.631808
2.33449×10	1.368192	1	0	1.00000×10^{3}	3.000000	1.00000×10^{6}	6.000000
2.33449×10^{-2}	0.368192	1.00000×10^{-3}	$\bar{3}.000000$	1	0	1.00000×10^{3}	3.000000
2.33449×10^{-5}	$\bar{5}.368192$	1.00000×10^{-6}	$\bar{6}.000000$	1.00000×10^{-3}	$\bar{3}.000000$	1	0

TABLE 37. — Magnetic Moment, etc.

Dimensions = $M^{\frac{1}{2}}L^{\frac{5}{2}}T^{-1}$.

Foot Grain Second Units.		Metre Gramme Second Units.		Centimetre Gramme Second Units.		Millimetre Milligramme Second Units.	
No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0	1.30564×10^{-2}	$\bar{2}.115823$	1.30564×10^{3}	3.115823	1.30564×10^{7}	7.115823
7.65908×10	1.884177	1	0	1.00000×10	1.000000	1.00000×10^{5}	5.000000
7.65908×10^{-4}	$\bar{4}.884177$	1.00000×10^{-1}	$\bar{1}.000000$	1	0	1.00000×10^{4}	4.000000
7.65908×10^{-8}	$\bar{8}.884177$	1.00000×10^{-5}	$\bar{5}.000000$	1.00000×10^{-4}	$\bar{4}.000000$	1	0

HYPERBOLIC FUNCTIONS.*

Hyperbolic sines. **Values of $\frac{e^x - e^{-x}}{2}$.**

x	0	1	2	3	4	5	6	7	8	9
0.0	0.0000	0.0100	0.0200	0.0300	0.0400	0.0500	0.0600	0.0701	0.0801	0.0901
0.1	.1002	.1102	.1203	.1304	.1405	.1506	.1607	.1708	.1810	.1911
0.2	.2013	.2115	.2218	.2320	.2423	.2526	.2629	.2733	.2837	.2941
0.3	.3045	.3150	.3255	.3360	.3466	.3572	.3678	.3785	.3892	.4000
0.4	.4108	.4216	.4325	.4434	.4543	.4653	.4764	.4875	.4986	.5098
0.5	0.5211	0.5324	0.5438	0.5552	0.5666	0.5782	0.5897	0.6014	0.6131	0.6248
0.6	.6367	.6485	.6605	.6725	.6846	.6967	.7090	.7213	.7336	.7461
0.7	.7586	.7712	.7838	.7966	.8094	.8223	.8353	.8484	.8615	.8748
0.8	.8881	.9015	.9150	.9286	.9423	.9561	.9700	.9840	.9981	.0122
0.9	1.0265	1.0409	1.0554	1.0700	1.0847	1.0995	1.1144	1.1294	1.1446	1.1598
1.0	1.1752	1.1907	1.2063	1.2220	1.2379	1.2539	1.2700	1.2862	1.3025	1.3190
1.1	.3356	.3524	.3693	.3863	.4035	.4208	.4382	.4558	.4735	.4914
1.2	.5095	.5276	.5460	.5645	.5831	.6019	.6209	.6400	.6593	.6788
1.3	.6984	.7182	.7381	.7583	.7786	.7991	.8198	.8406	.8617	.8829
1.4	.9043	.9259	.9477	.9697	.9919	2.0143	2.0369	2.0597	2.0827	2.1059
1.5	2.1293	2.1529	2.1768	2.2008	2.2251	2.2496	2.2743	2.2993	2.3245	2.3499
1.6	.3756	.4015	.4276	.4540	.4806	.5075	.5346	.5620	.5896	.6175
1.7	.6456	.6740	.7027	.7317	.7609	.7904	.8202	.8503	.8806	.9112
1.8	.9422	.9734	3.0049	3.0367	3.0689	3.1013	3.1340	3.1671	3.2005	3.2341
1.9	3.2682	3.3025	.3372	.3722	.4075	.4432	.4792	.5156	.5523	.5894
2.0	3.6269	3.6647	3.7028	3.7414	3.7803	3.8196	3.8593	3.8993	3.9398	3.9806
2.1	4.0219	4.0635	4.1056	4.1480	4.1909	4.2342	4.2779	4.3221	4.3666	4.4117
2.2	4.4571	4.5030	4.5494	4.5962	4.6434	4.6912	4.7394	4.7880	4.8372	4.8868
2.3	4.9370	4.9876	5.0387	5.0903	5.1425	5.1951	5.2483	5.3020	5.3562	5.4109
2.4	5.4662	5.5221	5.5785	5.6354	5.6929	5.7510	5.8097	5.8689	5.9288	5.9892
2.5	6.0502	6.1118	6.1741	6.2369	6.3004	6.3645	6.4293	6.4946	6.5607	6.6274
2.6	6.6947	6.7628	6.8315	6.9009	6.9709	7.0417	7.1132	7.1854	7.2583	7.3319
2.7	7.4063	7.4814	7.5572	7.6338	7.7112	7.7894	7.8683	7.9480	8.0285	8.1098
2.8	8.1919	8.2749	8.3586	8.4432	8.5287	8.6150	8.7021	8.7902	8.8791	8.9689
2.9	9.0596	9.1512	9.2437	9.3371	9.4315	9.5268	9.6231	9.7203	9.8185	9.9177
3.0	10.018	10.119	10.221	10.324	11.429	11.534	11.640	11.748	11.856	11.966
3.1	11.076	11.188	11.301	11.415	11.530	12.647	12.764	12.883	12.003	12.124
3.2	12.246	12.369	12.494	12.620	12.747	12.876	13.006	13.137	13.269	13.403
3.3	13.538	13.674	13.812	13.951	14.092	14.234	14.377	14.522	14.668	14.816
3.4	14.965	15.116	15.268	15.422	15.577	15.734	15.893	16.053	16.214	16.378
3.5	16.543	16.709	16.877	17.047	17.219	17.392	17.567	17.744	17.923	18.103
3.6	18.285	18.470	18.655	18.843	19.033	19.224	19.418	19.613	19.811	20.010
3.7	20.211	20.415	20.620	20.828	21.037	21.249	21.463	21.679	21.897	22.117
3.8	22.339	22.564	22.791	23.020	23.252	23.486	23.722	23.961	24.202	24.445
3.9	24.691	24.939	25.190	25.444	25.700	25.958	26.219	26.483	26.749	27.018
4.0	27.290	27.564	27.842	28.122	28.404	28.690	28.979	29.270	29.564	29.862
4.1	30.162	30.465	30.772	31.081	31.393	31.709	32.028	32.350	32.675	33.004
4.2	33.336	33.671	34.009	34.351	34.697	35.046	35.398	35.754	36.113	36.476
4.3	36.843	37.214	37.588	37.966	38.347	38.733	39.122	39.515	39.913	40.314
4.4	40.719	41.129	41.542	41.960	42.382	42.808	43.238	43.673	44.112	44.555
4.5	45.003	45.455	45.912	46.374	46.840	47.311	47.787	48.267	48.752	49.242
4.6	49.737	50.237	50.742	51.252	51.767	52.288	52.813	53.344	53.880	54.422
4.7	54.969	55.522	56.080	56.643	57.213	57.788	58.369	58.955	59.548	60.147
4.8	60.751	61.362	61.979	62.601	63.231	63.866	64.508	65.157	65.812	66.473
4.9	67.141	67.816	68.498	69.186	69.882	70.584	71.293	72.010	72.734	73.465

* Tables 38–41 are quoted from "Des Ingenieurs Taschenbuch," herausgegeben vom Akademischen Verein (Hütte).

HYPERBOLIC FUNCTIONS.

Hyperbolic cosines. **Values of $\frac{e^x+e^{-x}}{2}$.**

x	0	1	2	3	4	5	6	7	8	9
0.0	1.0000	1.0001	1.0002	1.0005	1.0008	1.0013	1.0018	1.0025	1.0032	1.0041
0.1	.0050	.0061	.0072	.0085	.0098	.0113	.0128	.0145	.0162	.0181
0.2	.0201	.0221	.0243	.0266	.0289	.0314	.0340	.0367	.0395	.0423
0.3	.0453	.0484	.0516	.0549	.0584	.0619	.0655	.0692	.0731	.0770
0.4	.0811	.0852	.0895	.0939	.0984	.1030	.1077	.1125	.1174	.1225
0.5	1.1276	1.1329	1.1383	1.1438	1.1494	1.1551	1.1609	1.1669	1.1730	1.1792
0.6	.1855	.1919	.1984	.2051	.2119	.2188	.2258	.2330	.2402	.2476
0.7	.2552	.2628	.2706	.2785	.2865	.2947	.3030	.3114	.3199	.3286
0.8	.3374	.3464	.3555	.3647	.3740	.3835	.3932	.4029	.4128	.4229
0.9	.4331	4434	.4539	.4645	.4753	.4862	.4973	.5085	.5199	.5314
1.0	1.5431	1.5549	1.5669	1.5790	1.5913	1.6038	.6164	1.6292	1.6421	1.6552
1.1	.6685	.6820	.6956	.7093	.7233	.7374	.7517	.7662	.7808	.7956
1.2	.8107	.8258	.8412	.8568	.8725	.8884	.9045	.9208	.9373	.9540
1.3	.9709	.9880	2.0053	2.0228	2.0404	2.0583	2.0764	2.0947	2.1132	2.1320
1.4	2.1509	.1700	.1894	.2090	.2288	.2488	.2691	.2896	.3103	.3312
1.5	2.3524	2.3738	2.3955	2.4174	2.4395	2.4619	2.4845	2.5073	2.5305	2.5538
1.6	.5775	.6013	.6255	.6499	.6746	.6995	.7247	.7502	.7760	.8020
1.7	.8283	.8549	.8818	.9090	.9364	.9642	.9922	3.0206	3.0492	3.0782
1.8	3.1075	3.1371	3.1669	3.1972	3.2277	3.2585	3.2897	.3212	.3530	.3852
1.9	.4177	.4506	.4838	.5173	.5512	.5855	.6201	.6551	.6904	.7261
2.0	3.7622	3.7987	3.8355	3.8727	3.9103	3.9483	3.9867	4.0255	4.0647	4.1043
2.1	4.1443	4.1847	4.2256	4.2668	4.3085	4.3507	4.3932	4.4362	4.4797	4.5236
2.2	4.5679	4.6127	4.6580	4.7037	4.7499	4.7966	4.8437	4.8914	4.9395	4.9881
2.3	5.0372	5.0868	5.1370	5.1876	5.2388	5.2905	5.3427	5.3954	5.4487	5.5026
2.4	5.5569	5.6119	5.6674	5.7235	5.7801	5.8373	5.8951	5.9535	6.0125	6.0721
2.5	6.1323	6.1931	6.2545	6.3166	6.3793	6.4426	6.5066	6.5712	6.6365	6.7024
2.6	6.7690	6.8363	6.9043	6.9729	7.0423	7.1123	7.1831	7.2546	7.3268	7.3998
2.7	7.4735	7.5479	7.6231	7.6990	7.7758	7.8533	7.9136	7.0106	8.0905	8.1712
2.8	8.2527	8.3351	8.4182	8.5022	8.5871	8.6728	8.7594	8.8469	8.9352	9.0244
2.9	9.1146	9.2056	9.2976	9.3905	9.4844	9.5791	9.6749	9.7716	9.8693	9.9680
3.0	10.068	10.168	10.270	10.373	10.476	10.581	10.687	10.794	10.902	11.011
3.1	11.121	12.233	11.345	11.459	11.574	11.689	11.806	11.925	12.044	12.165
3.2	12.287	13.410	12.534	12.660	12.786	12.915	13.044	13.175	13.307	13.440
3.3	13.575	14.711	13.848	13.987	14.127	14.269	14.412	14.556	14.702	14.850
3.4	14.999	15.149	15.301	15.455	15.610	15.766	15.924	16.084	16.245	16.408
3.5	16.573	16.739	16.907	17.077	17.248	17.421	17.596	17.772	17.951	18.131
3.6	18.313	18.497	18.682	18.870	19.059	19.250	19.444	19.639	19.836	20.035
3.7	20.236	20.439	20.644	20.852	21.061	21.272	21.486	21.702	21.919	22.139
3.8	22.362	22.586	22.813	23.042	23.273	23.507	23.743	23.982	24.222	24.466
3.9	24.711	24.959	25.210	25.463	25.719	25.977	26.238	26.502	26.768	27.037
4.0	27.308	27.582	27.860	28.139	28.422	28.707	28.996	29.287	29.581	29.878
4.1	30.178	30.482	30.788	31.097	31.409	31.725	32.044	32.365	32.691	33 019
4.2	33.351	33.686	34.024	34.366	34.711	35.060	35.412	35.768	36.127	36.490
4.3	36.857	37.227	37.601	37.979	38.360	38.746	39.135	39.528	39.925	40.326
4.4	40.732	41.141	41.554	41.972	42.393	42.819	43.250	43.684	44.123	44.566
4.5	45.014	45.466	45.923	46.385	46.851	47.321	47.797	48.277	48.762	49.252
4.6	49.747	50.247	50.752	51.262	51.777	52.297	52.823	53.354	53.890	54.431
4.7	54.978	55.531	56.089	56.652	57.221	57.796	58.377	58.964	59.556	60.155
4.8	60.759	61.370	61.987	62.609	63.239	63.874	64.516	65.164	65.819	66.481
4.9	67.149	67.823	68.505	69.193	69.889	70.591	71.300	72.017	72.741	73.472

HYPERBOLIC FUNCTIONS.

Common logarithms + 10 of the hyperbolic sines.

x	0	1	2	3	4	5	6	7	8	9
0.0	8.——	0000	3011	4772	6022	6992	7784	8455	9036	9548
0.1	0007	0423	0802	1152	1475	1777	2060	2325	2576	2814
0.2	3039	3254	3459	3656	3844	4025	4199	4366	4528	4685
0.3	4836	4983	5125	5264	5398	5529	5656	5781	5902	6020
0.4	9.6136	6249	6359	6463	6574	6678	6780	6880	6978	7074
0.5	9.7169	7262	7354	7444	7533	7620	7707	7791	7875	7958
0.6	8039	8119	8199	8277	8354	8431	8506	8581	8655	8728
0.7	8800	8872	8942	9012	9082	9150	9218	9286	9353	9419
0.8	9485	9550	9614	9678	9742	9805	9868	9930	9992	0053
0.9	10.0114	0174	0234	0294	0353	0412	0470	0529	0586	0644
1.0	10.0701	0758	0815	0871	0927	0982	1038	1093	1148	1203
1.1	1257	1311	1365	1419	1472	1525	1578	1631	1684	1736
1.2	1788	1840	1892	1944	1995	2046	2098	2148	2199	2250
1.3	2300	2351	2401	2451	2501	2551	2600	2650	2699	2748
1.4	2797	2846	2895	2944	2993	3041	3090	3138	3186	3234
1.5	10.3282	3330	3378	3426	3474	3521	3569	3616	3663	3711
1.6	3758	3805	3852	3899	3946	3992	4039	4086	4132	4179
1.7	4225	4272	4318	4364	4411	4457	4503	4549	4595	4641
1.8	4687	4733	4778	4824	4870	4915	4961	5007	5052	5098
1.9	5143	5188	5234	5279	5324	5370	5415	5460	5505	5550
2.0	10.5595	5640	5685	5730	5775	5820	5865	5910	5955	5999
2.1	6044	6089	6134	6178	6223	6268	6312	6357	6401	6446
2.2	6491	6535	6580	6624	6668	6713	6757	6802	6846	6890
2.3	6935	6979	7023	7067	7112	7156	7200	7244	7289	7333
2.4	7377	7421	7465	7509	7553	7597	7642	7686	7730	7774
2.5	10.7818	7862	7906	7950	7994	8038	8082	8126	8169	8213
2.6	8257	8301	8345	8389	8433	8477	8521	8564	8608	8652
2.7	8696	8740	8784	8827	8871	8915	8959	9003	9046	9090
2.8	9134	9178	9221	9265	9309	9353	9396	9440	9484	9527
2.9	9571	9615	9658	9702	9746	9789	9833	9877	9920	9964
3.0	11.0008	0051	0095	0139	0182	0226	0270	0313	0357	0400
3.1	0444	0488	0531	0575	0618	0662	0706	0749	0793	0836
3.2	0880	0923	0967	1011	1054	1098	1141	1185	1228	1272
3.3	1316	1359	1403	1446	1490	1533	1577	1620	1664	1707
3.4	1751	1794	1838	1881	1925	1968	2012	2056	2099	2143
3.5	11.2186	2230	2273	2317	2360	2404	2447	2491	2534	2578
3.6	2621	2665	2708	2752	2795	2839	2882	2925	2969	3012
3.7	3056	3099	3143	3186	3230	3273	3317	3360	3404	3447
3.8	3491	3534	3578	3621	3665	3708	3752	3795	3838	3882
3.9	3925	3969	4012	4056	4099	4143	4186	4230	4273	4317
4.0	11.4360	4403	4447	4490	4534	4577	4621	4664	4708	4751
4.1	4795	4838	4881	4925	4968	5012	5055	5099	5142	5186
4.2	5229	5273	5316	5359	5403	5446	5490	5533	5577	5620
4.3	5664	5707	5750	5794	5837	5881	5924	5968	6011	6055
4.4	6098	6141	6185	6228	6272	6315	6359	6402	6446	6489
4.5	11.6532	6576	6619	6663	6706	6750	6793	6836	6880	6923
4.6	6967	7010	7054	7097	7141	7184	7227	7271	7314	7358
4.7	7401	7445	7488	7531	7575	7618	7662	7705	7749	7792
4.8	7836	7879	7922	7966	8009	8053	8096	8140	8183	8226
4.9	8270	8313	8357	8400	8444	8487	8530	8574	8617	8661

HYPERBOLIC FUNCTIONS.

Common logarithms of the hyperbolic cosines.

x	0	1	2	3	4	5	6	7	8	9
0.0	0.0000	0000	0001	0002	0003	0005	0008	0011	0014	0018
0.1	0022	0026	0031	0037	0042	0049	0055	0062	0070	0078
0.2	0086	0095	0104	0114	0124	0134	0145	0156	0168	0180
0.3	0193	0205	0219	0232	0246	0261	0276	0291	0306	0322
0.4	0339	0355	0372	0390	0407	0426	0444	0463	0482	0502
0.5	0.0522	0542	0562	0583	0605	0626	0648	0670	0693	0716
0.6	0739	0762	0786	0810	0835	0859	0884	0910	0935	0961
0.7	0987	1013	1040	1067	1094	1122	1149	1177	1206	1234
0.8	1263	1292	1321	1350	1380	1410	1440	1470	1501	1532
0.9	1563	1594	1625	1657	1689	1721	1753	1785	1818	1851
1.0	0.1884	1917	1950	1984	2018	2051	2086	2120	2154	2189
1.1	2223	2258	2293	2328	2364	2399	2435	2470	2506	2542
1.2	2578	2615	2651	2688	2724	2761	2798	2835	2872	2909
1.3	2947	2984	3022	3059	3097	3135	3173	3211	3249	3288
1.4	3326	3365	3403	3442	3481	3520	3559	3598	3637	3676
1.5	0.3715	3754	3794	3833	3873	3913	3952	3992	4032	4072
1.6	4112	4152	4192	4232	4273	4313	4353	4394	4434	4475
1.7	4515	4556	4597	4637	4678	4719	4760	4801	4842	4883
1.8	4924	4965	5006	5048	5089	5130	5172	5213	5254	5296
1.9	5337	5379	5421	5462	5504	5545	5587	5629	5671	5713
2.0	0.5754	5796	5838	5880	5922	5964	6006	6048	6090	6132
2.1	6175	6217	6259	6301	6343	6386	6428	6470	6512	6555
2.2	6597	6640	6682	6724	6767	6809	6852	6894	6937	6979
2.3	7022	7064	7107	7150	7192	7235	7278	7320	7363	7406
2.4	7448	7491	7534	7577	7619	7662	7705	7748	7791	7833
2.5	0.7876	7919	7962	8005	8048	8091	8134	8176	8219	8262
2.6	8305	8348	8391	8434	8477	8520	8563	8606	8649	8692
2.7	8735	8778	8821	8864	8907	8951	8994	9037	9080	9123
2.8	9166	9209	9252	9295	9338	9382	9425	9468	9511	9554
2.9	9597	9641	9684	9727	9770	9813	9856	9900	9943	9986
3.0	1.0029	0073	0116	0159	0202	0245	0289	0332	0375	0418
3.1	0462	0505	0548	0591	0635	0678	0721	0764	0808	0851
3.2	0894	0938	0981	1024	1067	1111	1154	1197	1241	1284
3.3	1327	1371	1414	1457	1501	1544	1587	1631	1674	1717
3.4	1761	1804	1847	1891	1934	1977	2021	2064	2107	2151
3.5	1.2194	2237	2281	2324	2367	2411	2454	2497	2541	2584
3.6	2628	2671	2714	2758	2801	2844	2888	2931	2974	3018
3.7	3061	3105	3148	3191	3235	3278	3322	3365	3408	3452
3.8	3495	3538	3582	3625	3669	3712	3755	3799	3842	3886
3.9	3929	3972	4016	4059	4103	4146	4189	4233	4278	4320
4.0	1.4363	4406	4450	4493	4537	4580	4623	4667	4710	4754
4.1	4797	4840	4884	4927	4971	5014	5057	5101	5144	5188
4.2	5231	5274	5318	5361	5405	5448	5492	5535	5578	5622
4.3	5665	5709	5752	5795	5839	5882	5926	5969	6012	6056
4.4	6099	6143	6186	6230	6273	6316	6360	6403	6447	6490
4.5	1.6533	6577	6620	6664	6707	6751	6794	6837	6881	6924
4.6	6968	7011	7055	7098	7141	7185	7228	7272	7315	7358
4.7	7402	7445	7489	7532	7576	7619	7662	7706	7749	7793
4.8	7836	7880	7923	7966	8010	8053	8097	8140	8184	8227
4.9	8270	8314	8357	8401	8444	8487	8531	8574	8618	8661

EXPONENTIAL FUNCTIONS.

Values of e^x and of e^{-x} and their logarithms.

Values of e^x and e^{-x} for values of x intermediate to those here given may be found by adding or subtracting the values of the hyperbolic cosine and sine given in Tables 38–39.

x	e^x	log e^x	x	e^x	log e^x	x	e^{-x}	log e^{-x}
0.1	1.1052	0.04343	**5.1**	164.03	2.21490	**0.1**	0.90484	$\bar{1}.95657$
2	1.2214	08686	2	181.27	25833	2	81873	91314
3	1.3499	13029	3	200.34	30176	3	74082	86971
4	1.4918	17372	4	221.41	34519	4	67032	82628
5	1.6487	21715	5	244.69	38862	5	60653	78285
0.6	1.8221	0.26058	**5.6**	270.43	2.43205	**0.6**	0.54881	$\bar{1}.73942$
7	2.0138	30401	7	298.87	47548	7	49659	69599
8	2.2255	34744	8	330.30	51891	8	44933	65256
9	2.4596	39087	9	365.04	56234	9	40657	60913
1.0	2.7183	43429	6.0	403.43	60577	1.0	36788	56570
1.1	3.0042	0.47772	**6.1**	445.86	2.64920	**1.1**	0.33287	$\bar{1}.52228$
2	3.3201	52115	2	492.75	69263	2	30119	47885
3	3.6693	56458	3	545.57	73606	3	27253	43542
4	4.0552	60801	4	601.85	77948	4	24660	39199
5	4.4817	65144	5	665.14	82291	5	22313	34856
1.6	4.9530	0.69487	**6.6**	735.10	2.86634	**1.6**	0.20190	$\bar{1}.30513$
7	5.4739	73830	7	812.41	90977	7	18268	26170
8	6.0496	78173	8	897.85	95320	8	16530	21827
9	6.6859	82516	9	992.27	99663	9	14957	17484
2.0	7.3891	86859	7.0	1096.63	3.04006	2.0	13534	13141
2.1	8.1662	0.91202	**7.1**	1212.0	3.08349	**2.1**	0.12246	$\bar{1}.08798$
2	9.0250	95545	2	1339.4	12692	2	11080	04455
3	9.9742	99888	3	1480.3	17035	3	10026	00112
4	11.0232	1.04231	4	1636.0	21378	4	09073	$\bar{2}.95769$
5	12.1825	08574	5	1808.0	25721	5	08208	91426
2.6	13.463	1.12917	**7.6**	1998.2	3.30064	**2.6**	0.074274	$\bar{2}.87083$
7	14.880	17260	7	2208.3	34407	7	067205	82740
8	16.445	21602	8	2440.6	38750	8	060810	78398
9	18.174	25945	9	2697.3	43093	9	055023	74055
3.0	20.086	30288	8.0	2981.0	47436	3.0	049787	69712
3.1	22.198	1.34631	**8.1**	3294.5	3.51779	**3.1**	0.045049	$\bar{2}.65369$
2	24.533	38974	2	3641.0	56121	2	040762	61026
3	27.113	43317	3	4023.9	60464	3	036883	56683
4	29.964	47660	4	4447.1	64807	4	033373	52340
5	33.115	52003	5	4914.8	69150	5	030197	47997
3.6	36.598	1.56346	**8.6**	5431.7	3.73493	**3.6**	0.027324	$\bar{2}.43654$
7	40.447	60689	7	6002.9	77836	7	024724	39311
8	44.701	65032	8	6634.2	82179	8	022371	34968
9	49.402	69375	9	7332.0	86522	9	020242	30625
4.0	54.598	73718	9.0	8103.1	90865	4.0	018316	26282
4.1	60.340	1.78061	**9.1**	8955.	3.95208	**4.1**	0.016573	$\bar{2}.21939$
2	66.686	82404	2	9897.	99551	2	014996	17596
3	73.700	86747	3	10938.	4.03894	3	013569	13253
4	81.451	91090	4	12088.	08237	4	012277	08910
5	90.017	95433	5	13360.	12580	5	011109	04567
4.6	99.48	1.99775	**9.6**	14765.	4.16923	**4.6**	0.010052	$\bar{2}.00225$
7	109.95	2.04118	7	16318.	21266	7	009095	$\bar{3}.95882$
8	121.51	08461	8	18034.	25609	8	008230	91539
9	134.29	12804	9	19930.	29952	9	007447	87196
5.0	148.41	17147	10.0	22026.	34295	5.0	006738	82853

EXPONENTIAL FUNCTIONS.

Value of e^{x^2} and e^{-x^2} and their logarithms.

The equation to the probability curve is $y = e^{-x^2}$, where x may have any value, positive or negative, between zero and infinity.

x	e^{x^2}	log e^{x^2}	e^{-x^2}	log e^{-x^2}
0.1	1.0101	0.00434	0.99005	$\bar{1}$.99566
2	1.0408	01737	96079	98263
3	1.0904	03909	91393	96091
4	1.1735	06949	85214	93051
5	1.2840	10857	77880	89143
0.6	1.4333	0.15635	0.69768	$\bar{1}$.84365
7	1.6323	21280	61263	78720
8	1.8965	27795	52729	72205
9	2.2479	35178	44486	64822
1.0	2.7183	43429	36788	56571
1.1	3.3535	0.52550	0.29820	$\bar{1}$.47450
2	4.2207	62538	23693	37462
3	5.4195	73396	18452	26604
4	7.0993	85122	14086	14878
5	9.4877	97716	10540	02284
1.6	1.2936 × 10	1.11179	0.77306 × 10^{-1}	$\bar{2}$.88821
7	1.7993 "	25511	55576 "	74489
8	2.5534 "	40711	39164 "	59289
9	3.6996 "	56780	27052 "	43220
2.0	5.4598 "	73718	18316 "	26282
2.1	8.2269 "	1.91524	0.12155 "	$\bar{2}$.08476
2	1.2647 × 10^2	2.10199	79070 × 10^{-2}	$\bar{3}$.89801
3	1.9834 "	29742	50418 "	70258
4	3.1735 "	50154	31511 "	49846
5	5.1802 "	71434	19304 "	28566
2.6	8.6264 "	2.93583	0.11592 "	$\bar{3}$.06417
7	1.4656 × 10^3	3.16601	68233 × 10^{-3}	$\bar{4}$.83400
8	2.5402 "	40487	39367 "	59513
9	4.4918 "	65242	22263 "	34758
3.0	8.1031 "	90865	12341 "	09135
3.1	1.4913 × 10^4	4.17357	0.67055 × 10^{-4}	$\bar{5}$.82643
2	2.8001 "	44718	35713 "	55283
3	5.2960 "	72947	18644 "	27053
4	1.0482 × 10^5	5.02044	95402 × 10^{-5}	$\bar{6}$.97956
5	2.0898 "	32011	47851 "	67989
3.6	4.2507 "	5.62846	0.23526 "	$\bar{6}$.37154
7	8.8205 "	94549	11337 "	05451
8	1.8673 × 10^6	6.27121	53554 × 10^{-6}	$\bar{7}$.72879
9	4.0329 "	60562	24796 "	39438
4.0	8.8861 "	94871	11254 "	05129
4.1	1.9976 × 10^7	7.30049	0.50062 × 10^{-7}	$\bar{8}$.69951
2	4.5809 "	66095	21829 "	33905
3	1.0718 × 10^8	8.03011	93303 × 10^{-8}	$\bar{9}$.96989
4	2.5583 "	40796	39088 "	59204
5	6.2297 "	79447	16052 "	20553
4.6	1.5476 × 10^9	9.18967	0.64614 × 10^{-9}	$\overline{10}$.81033
7	3.9228 "	59357	25494 "	40643
8	1.0143 × 10^{10}	10.00615	98595 × 10^{-10}	$\overline{11}$.99385
9	2.6755 "	42741	37376 "	57259
5.0	7.2005 "	85736	13888 "	14264

TABLE 44.

EXPONENTIAL FUNCTIONS.

Values of $e^{\frac{\pi}{4}x}$ and $e^{-\frac{\pi}{4}x}$ and their logarithms.

x	$e^{\frac{\pi}{4}x}$	$\log e^{\frac{\pi}{4}x}$	$e^{-\frac{\pi}{4}x}$	$\log e^{-\frac{\pi}{4}x}$
1	2.1933	0.34109	0.45594	$\bar{1}$.65891
2	4.8105	.68219	.20788	.31781
3	1.0551 × 10	1.02328	.94780 × 10^{-1}	$\bar{2}$.97672
4	2.3141 "	.36438	.43214 "	.63562
5	5.0754 "	.70547	.19703 "	.29453
6	1.1132 × 10^2	2.04656	0.89833 × 10^{-2}	$\bar{3}$.95344
7	2.4415 "	.38766	.40958 "	.61234
8	5.3549 "	.72875	.18674 "	.27125
9	1.1745 × 10^3	3.06985	.85144 × 10^{-3}	$\bar{4}$.93015
10	2.5760 "	.41094	.38820 "	.58906
11	5.6498 "	3.75204	0.17700 "	$\bar{4}$.24796
12	1.2392 × 10^4	4.09313	.80699 × 10^{-4}	$\bar{5}$.90687
13	2.7168 "	.43422	.36794 "	.56578
14	5.9610 "	.77532	.16776 "	.22468
15	1.3074 × 10^5	5.11641	.76487 × 10^{-5}	$\bar{6}$.88359
16	2.8675 "	5.45751	0.34873 "	$\bar{6}$.54249
17	6.2893 "	.79860	.15900 "	.20140
18	1.3794 × 10^6	6.13969	.72495 × 10^{-6}	$\bar{7}$.86031
19	3.0254 "	.48079	.33053 "	.51921
20	6.6356 "	.82189	.15070 "	.17812

TABLE 45.

EXPONENTIAL FUNCTIONS.

Values of $e^{\frac{\sqrt{\pi}}{4}x}$ and $e^{-\frac{\sqrt{\pi}}{4}x}$ and their logarithms.

x	$e^{\frac{\sqrt{\pi}}{4}x}$	$\log e^{\frac{\sqrt{\pi}}{4}x}$	$e^{-\frac{\sqrt{\pi}}{4}x}$	$\log e^{-\frac{\sqrt{\pi}}{4}x}$
1	1.4429	0.19244	0.64203	$\bar{1}$.80756
2	2.4260	.38488	.41221	.61512
3	3.7786	.57733	.26465	.42267
4	5.8853	.76977	.16992	.23023
5	9.1666	.96221	.10909	.03779
6	14.277	1.15465	0.070041	$\bar{2}$.84535
7	22.238	.34709	.044968	.65291
8	34.636	.53953	.028871	.46047
9	53.948	.73198	.018536	.26802
10	84.027	.92442	.011901	.07558
11	130.87	2.11686	0.0076408	$\bar{3}$.88314
12	203.85	.30930	.0049057	.69070
13	317.50	.50174	.0031496	.49826
14	494.52	.69418	.0020222	.30582
15	770.24	.88663	.0012983	.11337
16	1199.7	3.07907	0.00083355	$\bar{4}$.92093
17	1868.5	.27151	.00053517	.72849
18	2910.4	.46395	.00034360	.53605
19	4533.1	.65639	.00022060	.34361
20	7060.5	.84883	.00014163	.15117

EXPONENTIAL FUNCTIONS.

Value of e^x and e^{-x} and their logarithms.

x	e^x	log e^x	e^{-x}	log e^{-x}
1/64	1.0157	0.00679	0.98450	$\bar{1}$.99321
1/32	.0317	.01357	.96923	.98643
1/16	.0645	.02714	.93941	.97286
1/10	.1052	.04343	.90484	.95657
1/9	.1175	.04825	.89484	.95175
1/8	1.1331	0.05429	0.88250	$\bar{1}$.94571
1/7	.1536	.06204	.86688	.93796
1/6	.1814	.07238	.84648	.92762
1/5	.2214	.08686	.81873	.91314
1/4	.2840	.10857	.77880	.89143
1/3	1.3956	0.14476	0.71653	$\bar{1}$.85524
1/2	.6487	.21715	.60653	.78285
3/4	2.1170	.32572	.47237	.67428
1	.7183	.43429	.36788	.56571
5/4	3.4903	.54287	.28650	.45713
3/2	4.4817	0.65144	0.22313	$\bar{1}$.34856
7/4	5.7546	.76002	.17377	.23998
2	7.3891	.86859	.13535	.13141
9/4	9.4877	.97716	.10540	.02284
5/2	12.1825	1.08574	.08208	$\bar{2}$.91426

TABLE 47.

LEAST SQUARES.*

Values of $P = \frac{2}{\sqrt{\pi}} \int_0^{hx} e^{-(hx)^2} d(hx)$

This table gives the value of P, the probability of an observational error having a value positive or negative equal to or less than x when h is the measure of precision, $P = \frac{2}{\sqrt{\pi}} \int_0^{hx} e^{-(hx)^2} d(hx)$

hx	1	2	3	4	5	6	7	8	9	10
0.0	.01128	.02256	.03384	.04511	.05637	.06762	.07886	.09008	.10128	.11246
0.1	.12362	.13476	.14587	.15695	.16800	.17901	.18999	.20094	.21184	.22270
0.2	.23352	.24430	.25502	.26570	.27633	.28690	.29742	.30788	.31828	.32863
0.3	.33891	.34913	.35928	.36936	.37938	.38933	.33921	.40901	.41874	.42839
0.4	.43797	.44747	.45689	.88623	.47548	.48466	.49375	.50275	.51167	.52050
0.5	.52924	.53790	.54646	.55494	.56332	.57162	.57982	.58792	.59594	.60386
0.6	.61168	.61941	.62705	.63459	.64203	.64938	.65663	.66378	.67084	.67780
0.7	.68467	.69143	.69810	.70468	.71116	.71754	.72382	.73001	.73610	.74210
0.8	.74800	.75381	.75952	.76514	.77067	.77610	.78144	.78669	.79184	.79691
0.9	.80188	.80677	.81156	.81627	.82089	.82542	.82987	.83423	.83851	.84270
1.0	.84681	.85084	.85478	.85865	.86244	.86614	.86977	.87333	.87680	.88020
1.1	.88353	.88679	.88997	.89308	.89612	.89910	.90200	.90484	.90761	.91031
1.2	.91296	.91553	.91805	.92051	.92290	.92524	.92751	.92973	.93190	.93401
1.3	.93606	.93807	.94001	.94191	.94376	.94556	.94731	.94902	.95067	.95229
1.4	.95385	.95538	.95686	.95830	.95970	.96105	.96237	.96365	.96490	.96610
1.5	.96728	.96841	.96952	.97059	.97162	.97263	.97360	.97455	.97546	.97635
1.6	.97721	.97804	.97884	.97962	.98038	.98110	.98181	.98249	.98315	.98379
1.7	.98441	.98500	.98558	.98613	.98667	.98719	.98769	.98817	.98864	.98909
1.8	.98952	.98994	.99035	.99074	.99111	.99147	.99182	.99216	.99248	.99279
1.9	.99309	.99338	.99366	.99392	.99418	.99443	.99466	.99489	.99511	.99532

* Tables 47–52 are for the most part quoted from Howe's "Formulæ and Methods used in the application of Least Squares."

TABLE 48.

LEAST SQUARES.

This table gives the values of the probability P, as defined in last table, corresponding to different values of x/r where r is the "probable error." The probable error r is equal to $0.47694/h$.

$\frac{x}{r}$	0	1	2	3	4	5	6	7	8	9
0.0	.00000	.00538	.01076	.01614	.02512	.02690	.03228	.03766	.04303	.04840
0.1	.05378	.05914	.06451	.06987	.07523	.08059	.08594	.09129	.09663	.10197
0.2	.10731	.11264	.11796	.12328	.12860	13391	.13921	.14451	.14980	.15508
0.3	.16035	.16562	.17088	.17614	.18138	.18662	.19185	.19707	.20229	.20749
0.4	.21268	.21787	.22304	.22821	.23336	.23851	.24364	.24876	.25388	.25898
0.5	.26407	.26915	.27421	.27927	.28431	.28934	.29436	.29936	.30435	.30933
0.6	.31430	.31925	.32419	.32911	.33402	.33892	.34380	.34866	.35352	.35835
0.7	.36317	.36798	.37277	.37755	.38231	.38705	.39178	.39649	.40118	.40586
0.8	.41052	.41517	.41979	.42440	.42899	.43357	.43813	.44267	.44719	.45169
0.9	.45618	.46064	.46509	.46952	.47393	.47832	.48270	48605	.49139	.49570
1.0	.50000	.50428	.50853	.51277	.51699	.52119	.52537	.52952	.53366	.53778
1.1	.54188	.54595	.55001	.55404	.55806	.56205	.56602	.56998	.57391	.57782
1.2	.58171	.58558	.58942	.59325	.59705	.60083	.60460	.60833	.61205	.61575
1.3	.61942	.62308	.62671	.63032	.63391	.63747	.64102	.64554	.64804	.65152
1.4	.65498	.65841	.66182	.66521	.66858	.67193	.67526	.67856	.68184	.68510
1.5	.68833	.69155	.69474	.69791	.70106	.70419	.70729	.71038	.71344	.71648
1.6	.71949	.72249	.72546	.72841	.73134	.73425	.73714	.74000	.74285	.74567
1.7	.74847	.75124	.75400	.75674	.75945	.76214	.76481	.76746	.77009	.77270
1.8	.77528	.77785	.78039	.78291	.78542	.78790	.79036	.79280	.79522	.79761
1.9	.79999	.80235	.80469	.80700	.80930	.81158	.81383	.81607	.81828	.82048
2.0	.82266	.82481	.82695	.82907	.83117	.83324	.83530	.83734	.83936	.84137
2.1	.84335	.84531	.84726	.84919	.85109	.85298	.85486	.85671	.85854	.86036
2.2	.86216	.86394	.86570	.86745	.86917	.87088	.87258	.87425	.87591	.87755
2.3	.87918	.88078	.88237	.88395	.88550	.88705	.88857	.89008	.89157	.89304
2.4	.89450	.89595	.89738	.89879	.90019	.90157	.90293	.90428	.90562	.90694
2.5	.90825	.90954	.91082	.91208	.91332	.91456	.91578	.91698	.91817	.91935
2.6	.92051	.92166	.92280	.92392	.92503	.92613	.92721	.92828	.92934	.93038
2.7	.93141	.93243	.93344	.93443	.93541	.93638	.93734	.93828	.93922	.94014
2.8	.94105	.94195	.94284	.94371	.94458	.94543	.94627	.94711	.94793	.94874
2.9	.94954	.95033	.95111	.95187	.95263	.95338	.95412	.95484	.95557	.95628
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
3	.95698	.96346	.96910	.97397	.97817	.98176	.98482	.98743	.98962	.99147
4	.99302	.99431	.99539	99627	.99700	.99760	.99808	.99848	.99879	.99905
5	.99926	.99943	.99956	.99966	.99974	.99980	.99985	.99988	.99991	.99993

TABLE 49.

LEAST SQUARES.

Values of the factor $0.6745\sqrt{\frac{1}{n-1}}$.

This factor occurs in the equation $e_s = 0.6745\sqrt{\frac{\Sigma y^2}{n-1}}$ for the probable error of a single observation, and other similar equations.

n	=	1	2	3	4	5	6	7	8	9
00			0.6745	0.4769	0.3894	0.3372	0.3016	0.2754	0.2549	0.2385
10	0.2248	0.2133	.2029	.1947	.1871	.1803	.1742	.1686	.1636	.1590
20	.1547	.1508	.1472	.1438	.1406	.1377	.1349	.1323	.1298	.1275
30	.1252	.1231	.1211	.1192	.1174	.1157	.1140	.1124	.1109	.1094
40	.1080	.1066	.1053	.1041	.1029	.1017	.1005	.0994	.0984	.0974
50	0.0964	0.0954	0.0944	0.0935	0.0926	0.0918	0.0909	0.0901	0.0893	0.0886
60	.0878	.0871	.0864	.0857	.0850	.0843	.0837	.0830	.0824	.0818
70	.0812	.0806	.0800	.0795	.0789	.0784	.0778	.0773	.0768	.0763
80	.0759	.0754	.0749	.0745	.0940	.0736	.0731	.0727	.0723	.0719
90	.0715	.0711	.0707	.0703	.0699	.0696	.0692	.0688	.0685	.0681

LEAST SQUARES.

Values of the factor $0.6745\sqrt{\frac{1}{n(n-1)}}$.

This factor occurs in the equation $e_m = 0.6745\sqrt{\frac{\Sigma v^2}{n(n-1)}}$ for the probable error of the arithmetic mean.

n	=	1	2	3	4	5	6	7	8	9
00			0.4769	0.2754	0.1947	0.1508	0.1231	0.1041	0.0901	0.0795
10	0.0711	0.0643	.0587	.0540	.0500	.0465	.0435	.0409	.0386	.0365
20	.0346	.0329	.0314	.0300	.0287	.0275	.0265	.0255	.0245	.0237
30	0.0229	0.0221	0.0214	0.0208	0.0201	0.0196	0.0190	0.0185	0.0180	0.0175
40	.0171	.0167	.0163	.0159	.0155	.0152	.0148	.0145	.0142	.0139
50	.0136	.0134	.0131	.0128	.0126	.0124	.0122	.0119	.0117	.0115

LEAST SQUARES.

Values of the factor $0.8453\sqrt{\frac{1}{n(n-1)}}$.

This factor occurs in the equation $e_s = 0.8453\frac{\Sigma v}{\sqrt{n(n-1)}}$ for the probable error of a single observation.

n	=	1	2	3	4	5	6	7	8	9
00			0.5978	0.3451	0.2440	0.1890	0.1543	0.1304	0.1130	0.0996
10	0.0891	0.0806	.0736	.0677	.0627	.0583	.0546	.0513	.0483	.0457
20	.0434	.0412	.0393	.0376	.0360	.0345	.0332	.0319	.0307	.0297
30	0.0287	0.0277	0.0268	0.0260	0.0252	0.0245	0.0238	0.0232	0.0225	0.0220
40	.0214	.0209	.0204	.0199	.0194	.0190	.0186	.0182	.0178	.0174
50	.0171	.0167	.0164	.0161	.0158	.0155	.0152	.0150	.0147	.0145

LEAST SQUARES.

Values of $0.8453\frac{1}{n\sqrt{n-1}}$.

This table gives the average error of the arithmetic mean when the probable error is one.

n	=	1	2	3	4	5	6	7	8	9
00			0.4227	0.1993	0.1220	0.0845	0.0630	0.0493	0.0399	0.0332
10	0.0282	0.0243	.0212	.0188	.0167	.0151	.0136	.0124	.0144	.0105
20	.0097	.0090	.0084	.0078	.0073	.0069	.0065	.0061	.0058	.0055
30	0.0052	0.0050	0.0047	0.0045	0.0043	0.0041	0.0040	0.0038	0.0037	0.0035
40	.0034	.0033	.0031	.0030	.0029	.0028	.0027	.0027	.0026	.0025
50	.0024	.0023	.0023	.0022	.0022	.0021	.0020	.0020	.0019	.0019

GAMMA FUNCTION.*

$$\text{Value of } \log \int_0^\infty e^{-x} x^{n-1} dx + 10.$$

Values of the logarithms + 10 of the "Second Eulerian Integral" (Gamma function) $\int_0^\infty e^{-x} x^{n-1} dx$ or $\log \Gamma(n) + 10$ for values of n between 1 and 2. When n has values not lying between 1 and 2 the value of the function can be readily calculated from the equation $\Gamma(n+1) = n\Gamma(n) = n(n-1) \ldots (n-r)\Gamma(n-r)$.

n	0	1	2	3	4	5	6	7	8	9
1.00	9.99———	97497	95001	92512	90030	87555	85087	82627	80173	77727
1.01	75287	72855	70430	68011	65600	63196	60799	58408	56025	53648
1.02	51279	48916	46561	44212	41870	39535	37207	34886	32572	30265
1.03	27964	25671	23384	21104	18831	16564	14305	12052	09806	07567
1.04	05334	03108	00889	98677	96471	94273	92080	89895	87716	85544
1.05	9.9883379	81220	79068	76922	74783	72651	70525	68406	66294	64188
1.06	62089	59996	57910	55830	53757	51690	49630	47577	45530	43489
1.07	41469	39428	37407	35392	33384	31382	29387	27398	25415	23449
1.08	21469	19506	17549	15599	13655	11717	09785	07860	05941	04029
1.09	02123	00223	98329	96442	94561	92686	90818	89856	87100	85250
1.10	9.9783407	81570	79738	77914	76095	74283	72476	70676	68882	67095
1.11	65313	63538	61768	60005	58248	56497	54753	53014	51281	49555
1.12	47834	46120	44411	42709	41013	39323	37638	35960	34288	32622
1.13	30962	29308	27659	26017	24381	22751	21126	19508	17896	16289
1.14	14689	13094	11505	09922	08345	06774	05209	03650	02096	00549
1.15	9.9699007	97471	95941	94417	92898	91386	89879	88378	86883	85393
1.16	83910	82432	80960	79493	78033	76578	75129	73686	72248	70816
1.17	69390	67969	66554	65145	63742	62344	60952	59566	58185	56810
1.18	55440	54076	52718	51366	50019	48677	47341	46011	44867	43368
1.19	42054	40746	39444	38147	36856	35570	34290	33016	31747	30483
1.20	9.9629225	27973	26725	25484	24248	23017	21792	20573	19358	18150
1.21	16946	15748	14556	13369	12188	11011	09841	08675	07515	06361
1.22	05212	04068	02930	01796	00669	99546	98430	97318	96212	95111
1.23	594015	92925	91840	90760	89685	88616	87553	86494	85441	84393
1.24	83350	82313	81280	80253	79232	78215	77204	76198	75197	74201
1.25	9.9573211	72226	71246	70271	69301	68337	67377	66423	65474	64530
1.26	63592	62658	61730	60806	59888	58975	58067	57165	56267	55374
1.27	54487	53604	52727	51855	50988	50126	49268	48416	47570	46728
1.28	45891	45059	44232	43410	42593	41782	40975	40173	39376	38585
1.29	37798	37016	36239	35467	34700	33938	33181	32439	31682	30940
1.30	9.9530203	29470	28743	28021	27303	26590	25883	25180	24482	23789
1.31	23100	22417	21739	21065	20396	19732	19073	18419	17770	17125
1.32	16485	15850	15220	14595	13975	13359	12748	12142	11540	10944
1.33	10353	09766	09184	08606	08034	07466	06903	06344	05791	05242
1.34	04698	04158	03624	03094	02568	02048	01532	01021	00514	00012
1.35	9.9499515	99023	98535	98052	97573	97100	96630	96166	95706	95251
1.36	94800	94355	93913	93477	93044	92617	92194	91776	91362	90953
1.37	90549	90149	89754	89363	88977	88595	88218	87846	87478	87115
1.38	86756	86402	86052	85707	85366	85030	84698	84371	84049	83731
1.39	83417	83108	82803	82503	82208	81916	81630	81348	81070	80797
1.40	9.9480528	80263	80003	79748	79497	79250	79008	78770	78537	78308
1.41	78084	77864	77648	77437	77230	77027	76829	76636	76446	76261
1.42	76081	75905	75733	75565	75402	75243	75089	74939	74793	74652
1.43	74515	74382	74254	74130	74010	73894	73783	73676	93574	73746
1.44	73382	73292	73207	73125	73049	72976	72908	72844	72784	72728

* Quoted from Carr's "Synopsis of Mathematics," and is there quoted from Legendre's "Exercises de Calcul Intégral," tome ii.

GAMMA FUNCTION.

n	0	1	2	3	4	5	6	7	8	9
1.45	9.9472677	72630	72587	72549	72514	72484	72459	72437	72419	72406
1.46	72397	72393	72392	72396	72404	72416	72432	72452	72477	72506
1.47	72539	72576	72617	72662	72712	72766	72824	72886	72952	73022
1.48	73097	73175	73258	73345	73436	73531	73630	73734	73841	73953
1.49	74068	74188	74312	74440	74572	74708	74848	74992	75141	75293
1.50	9.9475449	75610	75774	75943	76116	76292	76473	76658	76847	77040
1.51	77237	77438	77642	77851	78064	78281	78502	78727	78956	79189
1.52	79426	79667	79912	80161	80414	80671	80932	81196	81465	81735
1.53	82015	82295	82580	82868	83161	83457	83758	84062	84370	84682
1.54	84998	85318	85642	85970	86302	86638	86977	87321	87668	88019
1.55	9.9488374	88733	89096	89463	89834	90208	90587	90969	91355	91745
1.56	92139	92537	92938	93344	93753	94166	94583	95004	95429	95857
1.57	96289	96725	97165	97609	98056	98508	98963	99422	99885	00351
1.58	500822	01296	01774	02255	02741	03230	03723	04220	04720	05225
1.59	05733	06245	06760	07280	07803	08330	08860	09395	09933	10475
1.60	9.9511020	11569	12122	12679	13240	13804	14372	14943	15519	16098
1.61	16680	17267	17857	18451	19048	19650	20254	20862	21475	22091
1.62	22710	23333	23960	24591	25225	25863	26504	27149	27798	28451
1.63	29107	29767	30430	31097	31767	32442	33120	33801	34486	35175
1.64	35867	36563	37263	37966	38673	39383	40097	40815	41536	42260
1.65	9.9542989	43721	44456	45195	45938	46684	47434	48187	48944	49704
1.66	50468	51236	52007	52782	53560	54342	55127	55916	56708	57504
1.67	58303	59106	59913	60723	61536	62353	63174	63998	64826	65656
1.68	66491	67329	68170	69015	69864	70716	71571	72430	73293	74159
1.69	75028	75901	76777	77657	78540	79427	80317	81211	82108	83008
1.70	9.9583912	84820	85731	86645	87536	88484	89409	90337	91268	92203
1.71	93141	94083	95028	95977	96929	97884	98843	99805	00771	01740
1.72	602712	03688	04667	05650	06636	07625	08618	09614	10613	11616
1.73	12622	13632	14645	15661	16681	17704	18730	19760	20793	21830
1.74	22869	23912	24959	26009	27062	28118	29178	30241	31308	32377
1.75	9.9633451	34527	35607	36690	37776	38866	39959	41055	42155	43258
1.76	44364	45473	46586	47702	48821	49944	51070	52200	53331	54467
1.77	55606	56749	57894	59043	60195	61350	62509	63671	64836	66004
1.78	67176	68351	69529	70710	71895	73082	74274	75468	76665	77866
1.79	79070	80277	81488	82701	83198	85138	86361	87588	88818	90051
1.80	9.9691287	92526	93768	95014	96263	97515	98770	00029	01291	02555
1.81	703823	05095	06369	07646	08927	10211	11498	12788	14082	15378
1.82	16678	17981	19287	20596	21908	23224	24542	25864	27189	28517
1.83	29848	31182	32520	33860	35204	36551	37900	39254	40610	41969
1.84	43331	44697	46065	47437	48812	50190	51571	52955	54342	55733
1.85	9.9757126	58522	59922	61325	62730	64140	65551	66966	68384	69805
1.86	71230	72657	74087	75521	76957	78397	79839	81285	82734	84186
1.87	85640	87098	88559	90023	91490	92960	94433	95910	97389	98871
1.88	800356	01844	03335	04830	06327	07827	09331	10837	12346	13859
1.89	15374	16893	18414	19939	21466	22996	24530	26066	27606	29148
1.90	9.9830693	32242	33793	35348	36905	38465	40028	41595	43164	44736
1.91	46311	47890	49471	51055	52642	54232	55825	57421	59020	60622
1.92	62226	63834	65445	67058	68675	70294	71917	73542	75170	76802
1.93	78436	80073	81713	83356	85002	86651	88302	89957	91614	93275
1.94	94938	96605	98274	99946	01621	03299	04980	06663	08350	10039
1.95	9.9911732	13427	15125	16826	18530	20237	21947	23659	25375	27093
1.96	28815	30539	32266	33995	35728	37464	39202	40943	42688	44435
1.97	46185	47937	49693	51451	53213	54977	56744	58513	60286	62062
1.98	63840	65621	67405	69192	70982	72774	74570	76368	78169	79972
1.99	81779	83588	85401	87216	89034	90854	92678	94504	96333	98165

GAMMA FUNCTION.*

Value of $\log \int_0^\infty e^{-x} x^{n-1} dx + 10$.

Values of the logarithms + 10 of the "Second Eulerian Integral" (Gamma function) $\int_0^\infty e^{-x} x^{n-1} dx$ or $\log \Gamma(n) + 10$ for values of n between 1 and 2. When n has values not lying between 1 and 2 the value of the function can be readily calculated from the equation $\Gamma(n+1) = n\Gamma(n) = n(n-1) \ldots (n-r)\Gamma(n-r)$.

n	0	1	2	3	4	5	6	7	8	9
1.00	9.99———	97497	95001	92512	90030	87555	85087	82627	80173	77727
1.01	75287	72855	70430	68011	65600	63196	60799	58408	56025	53648
1.02	51279	48916	46561	44212	41870	39535	37207	34886	32572	30265
1.03	27964	25671	23384	21104	18831	16564	14305	12052	09806	07567
1.04	05334	03108	00889	98677	96471	94273	92080	89895	87716	85544
1.05	9.9883379	81220	79068	76922	74783	72651	70525	68406	66294	64188
1.06	62089	59996	57910	55830	53757	51690	49630	47577	45530	43489
1.07	41469	39428	37407	35392	33384	31382	29387	27398	25415	23449
1.08	21469	19506	17549	15599	13655	11717	09785	07860	05941	04029
1.09	02123	00223	98329	96442	94561	92686	90818	89856	87100	85250
1.10	9.9783407	81570	79738	77914	76095	74283	72476	70676	68882	67095
1.11	65313	63538	61768	60005	58248	56497	54753	53014	51281	49555
1.12	47834	46120	44411	42709	41013	39323	37638	35960	34288	32622
1.13	30962	29308	27659	26017	24381	22751	21126	19508	17896	16289
1.14	14689	13094	11505	09922	08345	06774	05209	03650	02096	00549
1.15	9.9699007	97471	95941	94417	92898	91386	89879	88378	86883	85393
1.16	83910	82432	80960	79493	78033	76578	75129	73686	72248	70816
1.17	69390	67969	66554	65145	63742	62344	60952	59566	58185	56810
1.18	55440	54076	52718	51366	50019	48677	47341	46011	44867	43368
1.19	42054	40746	39444	38147	36856	35570	34290	33016	31747	30483
1.20	9.9629225	27973	26725	25484	24248	23017	21792	20573	19358	18150
1.21	16946	15748	14556	13369	12188	11011	09841	08675	07515	06361
1.22	05212	04068	02930	01796	00669	99546	98430	97318	96212	95111
1.23	594015	92925	91840	90760	89685	88016	87553	86494	85441	84393
1.24	83350	82313	81280	80253	79232	78215	77204	76198	75197	74201
1.25	9.9573211	72226	71246	70271	69301	68337	67377	66423	65474	64530
1.26	63592	62658	61730	60806	59888	58975	58067	57165	56267	55374
1.27	54487	53604	52727	51855	50988	50126	49268	48416	47570	46728
1.28	45891	45059	44232	43410	42593	41782	40975	40173	39376	38585
1.29	37798	37016	36239	35467	34700	33938	33181	32439	31682	30940
1.30	9.9530203	29470	28743	28021	27303	26590	25883	25180	24482	23789
1.31	23100	22417	21739	21065	20396	19732	19073	18419	17770	17125
1.32	16485	15850	15220	14595	13975	13359	12748	12142	11540	10944
1.33	10353	09766	09184	08606	08034	07466	06903	06344	05791	05242
1.34	04698	04158	03624	03094	02568	02048	01532	01021	00514	00012
1.35	9.9499515	99023	98535	98052	97573	97100	96630	96166	95706	95251
1.36	94800	94355	93913	93477	93044	92617	92194	91776	91362	90953
1.37	90549	90149	89754	89363	88977	88595	88218	87846	87478	87115
1.38	86756	86402	86052	85707	85366	85030	84698	84371	84049	83731
1.39	83417	83108	82803	82503	82208	81916	81630	81348	81070	80797
1.40	9.9480528	80263	80003	79748	79497	79250	79008	78770	78537	78308
1.41	78084	77864	77648	77437	77230	77027	76829	76636	76446	76261
1.42	76081	75905	75733	75565	75402	75243	75089	74939	74793	74652
1.43	74515	74382	74254	74130	74010	73894	73783	73676	93574	73746
1.44	73382	73292	73207	73125	73049	72976	72908	72844	72784	72728

* Quoted from Carr's "Synopsis of Mathematics," and is there quoted from Legendre's "Exercises de Calcul Intégral," tome ii.

ELLIPTIC INTEGRALS.

Values of $\int_0^{\frac{\pi}{2}}(1-\sin^2\theta\sin^2\phi)^{\pm\frac{1}{2}}\,d\phi$.

This table gives the values of the integrals between 0 and $\pi/2$ of the function $(1-\sin^2\theta\sin^2\phi)^{\pm\frac{1}{2}}\,d\phi$ for different values of the modulus corresponding to each degree of θ between 0 and 90.

θ	$\int_0^{\frac{\pi}{2}}\frac{d\phi}{(1-\sin^2\theta\sin^2\phi)^{\frac{1}{2}}}$ Number.	Log.	$\int_0^{\frac{\pi}{2}}(1-\sin^2\theta\sin^2\phi)^{\frac{1}{2}}d\phi$ Number.	Log.	θ	$\int_0^{\frac{\pi}{2}}\frac{d\phi}{(1-\sin^2\theta\sin^2\phi)^{\frac{1}{2}}}$ Number.	Log.	$\int_0^{\frac{\pi}{2}}(1-\sin^2\theta\sin^2\phi)^{\frac{1}{2}}d\phi$ Number.	Log.
0°	1.5708	0.196120	1.5708	0.196120	45°	1.8541	0.268127	1.3506	0.130541
1	5709	196153	5707	196087	6	8691	271644	3418	127690
2	5713	196252	5703	195988	7	8848	275267	3329	124788
3	5719	196418	5697	195822	8	9011	279001	3238	121836
4	5727	196649	5689	195591	9	9180	282848	3147	118836
5°	1.5738	0.196947	1.5678	0.195293	50°	1.9356	0.286811	1.3055	0.115790
6	5751	197312	5665	194930	1	9539	290895	2963	112698
7	5767	197743	5649	194500	2	9729	295101	2870	109563
8	5785	197241	5632	194004	3	9927	299435	2776	106386
9	5805	198806	5611	193442	4	2.0133	303901	2681	103169
10°	1.5828	0.199438	1.5589	0.192815	55°	2.0347	0.308504	1.2587	0.099915
1	5854	200137	5564	192121	6	0571	313247	2492	096626
2	5882	200904	5537	191302	7	0804	318138	2397	093303
3	5913	201740	5507	190537	8	1047	323182	2301	089950
[illegible]	5946	202643	5476	189646	9	1300	328384	2206	086569
[illegible]	[illegible]081	0.203615	1.5442	0.188690	60°	2.1565	0.333753	1.2111	0.083164
[illegible]	[illegible]	204657	5405	187668	1	1842	339295	2015	079738
[illegible]	[illegible]	205768	5367	186581	2	2132	345020	1920	076293
[illegible]	[illegible]	[illegible]06948	5326	185428	3	2435	350936	1826	072834
[illegible]	[illegible]	[illegible]200	5283	184210	4	2754	357053	1732	069364
[illegible]	[illegible]	[illegible]	[illegible].5238	0.182928	65°	2.3088	0.363384	1.1638	0.065889
[illegible]	[illegible]	[illegible]	[illegible]01	181580	6	3439	369940	1545	062412
[illegible]	[illegible]	[illegible]	[illegible]	180168	7	3809	376736	1453	058937
[illegible]	[illegible]	[illegible]	[illegible]	178691	8	4198	383787	1362	055472
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]7150	9	4610	391112	1272	052020
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	70°	2.5046	0.398730	1.1184	0.048589
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	5507	406665	1096	045183
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5998	414943	1011	041812
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6521	423596	0927	038481
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]081	[illegible]	0844	035200
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.031976
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]8819
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]498777	1.[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	512591	03[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]3699	527613	027[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]004	544120	0223	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]19	562514	0172	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]43995	[illegible]	[illegible]	0.583396	1.0127	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	141414	[illegible]	[illegible]	607751	0086	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]5	138778	[illegible]	[illegible]	637355	0053	[illegible]
[illegible]	[illegible]	[illegible]	3680	136086	[illegible]	[illegible]	676027	0026	[illegible]
[illegible]	[illegible]	[illegible]	3594	133340	[illegible]	[illegible]	[illegible]35192	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]68127	1.3506	0.130541	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ZONAL HARMONICS.*

The values of the first seven zonal harmonics are here given for every degree between $\theta = 0°$ and $\theta = 90°$.

θ	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7
0°	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1°	0.9998	0.9995	0.9991	0.9985	0.9977	0.9967	0.9955
2	.9994	.9982	.9963	.9939	.9909	.9872	.9829
3	.9986	.9959	.9918	.9863	.9795	.9713	.9617
4	.9976	.9927	.9854	.9758	.9638	.9495	.9329
5	.9962	.9886	.9773	.9623	.9437	.9216	.8961
6°	.9945	.9836	.9674	.9459	.9194	.8881	.8522
7	.9925	.9777	.9557	.9267	.8911	.8476	.7986
8	.9903	.9709	.9423	.9048	.8589	.8053	.7448
9	.9877	.9633	.9273	.8803	.8232	.7571	.6831
10	.9848	.9548	.9106	.8532	.7840	.7045	.6164
11°	.9816	.9454	.8923	.8238	.7417	.6483	.5461
12	.9781	.9352	.8724	.7920	.6966	.5892	.4732
13	.9744	.9241	.8511	.7582	.6489	.5273	.3940
14	.9703	.9122	.8283	.7224	.5990	.4635	.3219
15	.9659	.8995	.8042	.6847	.5471	.3982	.2454
16°	.9613	.8860	.7787	.6454	.4937	.3322	.1699
17	.9563	.8718	.7519	.6046	.4391	.2660	.0961
18	.9511	.8568	.7240	.5624	.3836	.2002	.0289
19	.9455	.8410	.6950	.5192	.3276	.1347	—.0443
20	.939[illegible]	.8245	.6649	.4750	.2715	.0719	—.1072
21°	.9336	.8074	.6338	.4300	.2156	.0107	—.1662
22	.9272	.7895	.6019	.3845	.1602	—.0481	—.2201
23	.9205	.7710	.5692	.3386	.1057	—.1038	—.2681
24	.9135	.7518	.5357	.2926	.0525	—.1559	—.3095
25	.9063	.7321	.5016	.2465	.0009	—.2053	—.3463
26°	.8988	.7117	.4670	.2007	—.0489	—.2478	—.3717
27	.8910	.6908	.4319	.1553	—.0964	—.2869	—.3921
28	.8829	.6694	.3964	.1105	—.1415	—.3211	—.4052
29	.8746	.6474	.3607	.0665	—.1839	—.3503	—.4114
30	.8660	.6250	.3248	.0234	—.2233	—.3740	—.4101
31°	.8572	.6021	.2887	—.0185	—.2595	—.3924	—.4022
32	.8480	.5788	.2527	—.0591	—.2923	—.4052	—.3876
33	.8387	.5551	.2167	—.0982	—.3216	—.4126	—.3670
34	.8290	.5310	.1809	—.1357	—.3473	—.4148	—.3409
35	.8192	.5065	.1454	—.1714	—.3691	—.4115	—.3096
36°	.8090	.4818	.1102	—.2052	—.3871	—.4031	—.2738
37	.7986	.4567	.0755	—.2370	—.4011	—.3898	—.2343
38	.7880	.4314	.0413	—.2666	—.4112	—.3719	—.1918
39	.7771	.4059	.0077	—.2940	—.4174	—.3497	—.1469
40	.7660	.3802	—.0252	—.3190	—.4197	—.3234	—.1003
41°	.7547	.3544	—.0574	—.3416	—.4181	—.2938	—.0534
42	.7431	.3284	—.0887	—.3616	—.4128	—.2611	—.0065
43	.7314	.3023	—.1191	—.3791	—.4038	—.2255	.0395
44	.7193	.2762	—.1485	—.3940	—.3914	—.1878	.0846
45	.7071	.2500	—.1768	—.4062	—.3757	—.1485	.1270

* Calculated by Prof. Perry (Phil. Mag. Dec. 1891). See also A. Gray, "Absolute Measurements in Electricity and Magnetism," vol. ii., part 2.

ZONAL HARMONICS.

θ	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7
46°	0.6947	0.2238	—.2040	—.4158	—.3568	—.1079	0.1666
47	.6820	.1977	—.2300	—.4252	—.3350	—.0645	.2054
48	.6691	.1716	—.2547	—.4270	—.3105	—.0251	.2349
49	.6561	.1456	—.2781	—.4286	—.2836	.0161	.2627
50	.6428	.1198	—.3002	—.4275	—.2545	.0563	.2854
51°	.6293	.0941	—.3209	—.4239	—.2235	.0954	.3031
52	.6157	.0686	—.3401	—.4178	—.1910	.1326	.3153
53	.6018	.0433	—.3578	—.4093	—.1571	.1677	.3221
54	.5878	.0182	—.3740	—.3984	—.1223	.2002	.3234
55	.5736	—.0065	—.3886	—.3852	—.0868	.2297	.3191
56°	.5592	—.0310	—.4016	—.3698	—.0510	.2559	.3095
57	.5446	—.0551	—.4131	—.3524	—.0150	.2787	.2949
58	.5299	—.0788	—.4229	—.3331	.0206	.2976	.2752
59	.5150	—.1021	—.4310	—.3119	.0557	.3125	.2511
60	.5000	—.1250	—.4375	—.2891	.0898	.3232	.2231
61°	.4848	—.1474	—.4423	—.2647	.1229	.3298	.1916
62	.4695	—.1694	—.4455	—.2390	.1545	.3321	.1571
63	.4540	—.1908	—.4471	—.2121	.1844	.3302	.1203
64	.4384	—.2117	—.4470	—.1841	.2123	.3240	.0818
65	.4226	—.2321	—.4452	—.1552	.2381	.3138	.0422
66°	.4067	—.2518	—.4419	—.1256	.2615	.2906	.0021
67	.3907	—.2710	—.4370	—.0955	.2824	.28[illegible]	—.0375
68	.3746	—.2896	—.4305	—.0650	.3005	.2605	—.0763
69	.3584	—.3074	—.4225	—.0344	.3158	.2361	—.1135
70	.3420	—.3425	—.4130	—.0038	.3281	.2089	—.1485
71°	.3256	—.3410	—.4021	.0267	.3373	.1786	—.1811
72	.3090	—.3568	—.3898	.0568	.3434	.1472	—.2099
73	.2924	—.3718	—.3761	.0864	.3463	.1144	—.2347
74	.2756	—.3860	—.3611	.1153	.3461	.0795	—.2559
75	.2588	—.3995	—.3449	.1434	.3427	.0431	—.2730
76°	.2419	—.4112	—.3275	.1705	.3362	.0076	—.2848
77	.2250	—.4241	—.3090	.1964	.3267	—.0284	—.2919
78	.2079	—.4352	—.2894	.2211	.3143	—.0644	—.2943
79	.1908	—.4454	—.2688	.2443	.2990	—.0989	—.2913
80	.1736	—.4548	—.2474	.2659	.2810	—.1321	—.2835
81°	.1564	—.4633	—.2251	.2859	.2606	—.1635	—.2709
82	.1392	—.4709	—.2020	.3040	.2378	—.1926	—.2536
83	.1219	—.4777	—.1783	.3203	.2129	—.2193	—.2321
84	.1045	—.4836	—.1539	.3345	.1861	—.2431	—.2067
85	.0872	—.4886	—.1291	.3468	.1577	—.2638	—.1779
86°	.0698	—.4927	—.1038	.3569	.1278	—.2811	—.1460
87	.0523	—.4959	—.0781	.3648	.0969	—.2947	—.1117
88	.0349	—.4982	—.0522	.3704	.0651	—.3045	—.0735
89	.0175	—.4995	—.0262	.3739	.0327	—.3105	—.0381
90	.0000	—.5000	—.0000	.3750	.0000	—.3125	—.0000

MUTUAL INDUCTANCE.*

Values of log $\frac{M}{4\pi\sqrt{aa'}}$.

Table of values of log $\frac{M}{4\pi\sqrt{aa'}}$ for facilitating the calculation of the mutual inductance M of two coaxial circles of radii a, a', at distance apart b. The table is calculated for intervals of 6′ in the value of $\cos^{-1}\left\{\frac{(a-a')^2+b^2}{(a+a')^2+b^2}\right\}^{\frac{1}{2}}$ from 60° to 90°.

	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′
60°	$\bar{1}$.4994783	5022651	5050505	5078345	5106173	5133989	5161791	5189582	5217361	5245128
61	5272883	5300628	5328361	5356084	5383796	5411498	5439190	5466872	5494545	5522209
62	5549864	5577510	5605147	5632776	5660398	5688011	5715618	5743217	5770809	5798394
63	5825973	5853546	5881113	5908675	5936231	5963782	5991322	6018871	6046408	6073942
64	6101472	6128998	6156522	6184042	6211560	6239076	6266589	6294101	6321612	6349121
65°	$\bar{1}$.6376629	6404137	6431645	6459153	6486660	6514169	6541678	6569189	6596701	6624215
66	6651732	6679250	6706772	6734296	6761824	6789356	6816891	6844431	6871976	6899526
67	6927081	6954642	6982209	7009782	7037362	7064949	7092544	7120146	7147756	7175375
68	7203003	7230640	7258286	7285942	7313609	7341287	7368975	7396675	7424387	7452111
69	7479848	7507597	7535361	7563138	7590929	7618735	7646556	7674392	7702245	7730114
70°	$\bar{1}$.7758000	7785903	7813823	7841762	7869720	7897696	7925692	7953709	7981745	8009803
71	8037882	8065983	8094107	8122253	8150423	8178617	8206836	8235080	8263349	8291645
72	8319967	8348316	8376693	8405099	8433534	8461998	8490493	8519018	8547575	8576164
73	8604785	8633440	8662129	8690852	8719611	8748406	8777237	8806106	8835013	8863958
74	8892943	8921969	8951036	8980144	9009295	9038489	9067728	9097012	9126341	9155717
75°	$\bar{1}$.9185141	9214613	9244135	9273707	9303330	9333005	9362733	9392515	9422352	9452246
76	9482196	9512205	9542272	9572400	9602590	9632841	9663157	9693537	9723983	9754497
77	9785079	9815731	9846454	9877249	9908118	9939062	9970082	$\overline{0001181}$	$\overline{0032359}$	$\overline{0063618}$
78	0.0094959	0126385	0157896	0189494	0221181	0252959	0284830	0316794	0348855	0381014
79	0413273	0445633	0478098	0510668	0543347	0576136	0609037	0642054	0675187	0708441
80°	0.0741816	0775316	0808944	0842702	0876592	0910619	0944784	0979091	1013542	1048142
81	1082893	1117799	1152863	1188089	1223481	1259043	1294778	1330691	1366786	1403067
82	1439539	1476207	1513075	1550149	1587434	1624935	1662658	1700609	1738794	1777219
83	1815890	1854815	1894001	1933455	1973184	2013197	2053502	2094108	2135026	2176259
84	2217823	2259728	2301983	2344600	2387591	2430970	2474748	2518940	2563561	2608626
85°	0.2654152	2700156	2746655	2793670	2841221	2889329	2938018	2987312	3037238	3087823
86	3139097	3191092	3243843	3297387	3351762	3407012	3463184	3520327	3578495	3637749
87	3698153	3759777	3822700	3887006	3952792	4020162	4089234	4160138	4233022	4308053
88	4385420	4465341	4548064	4633880	4723127	4816206	4913595	5015870	5123738	5238079
89	5360007	5490969	5632886	5788406	5961320	6157370	6385907	6663883	7027765	7586941

* Quoted from Gray's "Absolute Measurements in Electricity and Magnetism," vol. ii., p. 852.

ELLIPTIC INTEGRALS.

Values of $\int_0^{\frac{\pi}{2}}(1-\sin^2\theta\sin^2\phi)^{\pm\frac{1}{2}}\,d\phi$.

This table gives the values of the integrals between 0 and $\pi/2$ of the function $(1-\sin^2\theta\sin^2\phi)^{\pm\frac{1}{2}}\,d\phi$ for different values of the modulus corresponding to each degree of θ between 0 and 90.

θ	$\int_0^{\frac{\pi}{2}}\frac{d\phi}{(1-\sin^2\theta\sin^2\phi)^{\frac{1}{2}}}$		$\int_0^{\frac{\pi}{2}}(1-\sin^2\theta\sin^2\phi)^{\frac{1}{2}}d\phi$		θ	$\int_0^{\frac{\pi}{2}}\frac{d\phi}{(1-\sin^2\theta\sin^2\phi)^{\frac{1}{2}}}$		$\int_0^{\frac{\pi}{2}}(1-\sin^2\theta\sin^2\phi)^{\frac{1}{2}}d\phi$	
	Number.	Log.	Number.	Log.		Number.	Log.	Number.	Log.
0°	1.5708	0.196120	1.5708	0.196120	45°	1.8541	0.268127	1.3506	0.130541
1	5709	196153	5707	196087	6	8691	271644	3418	127690
2	5713	196252	5703	195988	7	8848	275267	3329	124788
3	5719	196418	5697	195822	8	9011	279001	3238	121836
4	5727	196649	5689	195591	9	9180	282848	3147	118836
5°	1.5738	0.196947	1.5678	0.195293	50°	1.9356	0.286811	1.3055	0.115790
6	5751	197312	5665	194930	1	9539	290895	2963	112698
7	5767	197743	5649	194500	2	9729	295101	2870	109563
8	5785	197241	5632	194004	3	9927	299435	2776	106386
9	5805	198806	5611	193442	4	2.0133	303901	2681	103169
10°	1.5828	0.199438	1.5589	0.192815	55°	2.0347	0.308504	1.2587	0.099915
1	5854	200137	5564	192121	6	0571	313247	2492	096626
2	5882	200904	5537	191302	7	0804	318138	2397	093303
3	5913	201740	5507	190537	8	1047	323182	2301	089950
4	5946	202643	5476	189646	9	1300	328384	2206	086569
15°	1.5981	0.203615	1.5442	0.188690	60°	2.1565	0.333753	1.2111	0.083164
6	6020	204657	5405	187668	1	1842	339295	2015	079738
7	6061	205768	5367	186581	2	2132	345020	1920	076293
8	6105	206948	5326	185428	3	2435	350936	1826	072834
9	6151	208200	5283	184210	4	2754	357053	1732	069364
20°	1.6200	0.209522	1.5238	0.182928	65°	2.3088	0.363384	1.1638	0.065889
1	6252	210916	5191	181580	6	3439	369940	1545	062412
2	6307	212382	5141	180168	7	3809	376736	1453	058937
3	6365	213921	5090	178691	8	4198	383787	1362	055472
4	6426	215533	5037	177150	9	4610	391112	1272	052020
25°	1.6490	0.217219	1.4981	0.175545	70°	2.5046	0.398730	1.1184	0.048589
6	6557	218981	4924	173876	1	5507	406665	1096	045183
7	6627	220818	4864	172144	2	5998	414943	1011	041812
8	6701	222732	4803	170348	3	6521	423596	0927	038481
9	6777	224723	4740	168489	4	7081	432660	0844	035200
30°	1.6858	0.226793	1.4675	0.166567	75°	2.7681	0.442176	1.0764	0.031976
1	6941	228943	4608	164583	6	8327	452196	0686	028819
2	7028	231173	4539	162537	7	9026	462782	0611	025740
3	7119	233485	4469	160429	8	9786	474008	0538	022749
4	7214	235880	4397	158261	9	3.0617	485967	0468	019858
35°	1.7312	0.238359	1.4323	0.156031	80°	3.1534	0.498777	1.0401	0.017081
6	7415	240923	4248	153742	1	2553	512591	0338	014432
7	7522	243575	4171	151393	2	3699	527613	0278	011927
8	7633	246315	4092	148985	3	5004	544120	0223	009584
9	7748	249146	4013	146519	4	6519	562514	0172	007422
40°	1.7868	0.252068	1.3931	0.143995	85°	3.8317	0.583396	1.0127	0.005465
1	7992	255085	3849	141414	6	4.0528	607751	0086	003740
2	8122	258197	3765	138778	7	3387	637355	0053	002278
3	8256	261406	3680	136086	8	7427	676027	0026	001121
4	8396	264716	3594	133340	9	5.4349	735192	0008	000326
45°	1.8541	0.268127	1.3506	0.130541	90°	∞	∞	1.0000	——

BRITISH UNITS.

Cross sections and weights of wires.

This table gives the cross section and weights in British units of copper, iron, and brass wires of the diameters given in the first column. For one tenth the diameter divide section and weights by 100. For ten times the diameter multiply by 100, and so on.

Diam. in Mils.	Area of cross section in Sq. Mils.	Copper — Density 8.90.			Iron — Density 7.80.			Brass — Density 8.56.		
		Pounds per Foot.	Log.	Feet per Pound.	Pounds per Foot.	Log.	Feet per Pound.	Pounds per Foot.	Log.	Feet per Pound.
10	78.54	.000303	$\bar{4}.48150$	3300.	.0002656	$\bar{4}.42420$	3765.	.0002915	$\bar{4}.46458$	3431.
11	95.03	0367	.56429	2727.	03214	.50697	3112.	03527	54735	2836.
12	113.10	0436	.63986	2291.	03825	.58257	2615.	04197	62295	2383.
13	132.73	0512	.70939	1953.	04488	.65208	2228.	04926	69246	2030.
14	153.94	0594	.77376	1683.	05206	.71646	1921.	05713	75684	1750.
15	176.71	.000682	$\bar{4}.83368$	1467.	.0005976	$\bar{4}.77637$	1674	.0006558	$\bar{4}.81675$	1525.
16	201.06	0776	.88974	1289.	06799	.83244	1471.	07461	.87282	1340.
17	226.98	0876	.94240	1142.	07675	.88510	1303.	08423	.92548	1187.
18	254.47	0982	.99205	1018.	08605	.93475	1162.	09443	.97513	1059.
19	283.53	1094	$\bar{3}.03902$	914.	09588	.98171	1043.	.0010522	$\bar{3}.02209$	950.
20	314.16	.001212	$\bar{3}.08357$	825.1	.001062	$\bar{3}.02626$	941.4	.001166	$\bar{3}.06664$	857.7
21	346.36	1336	.12594	748.3	1171	.06864	853.8	1285	.10902	778.0
22	380.13	1467	.16634	681.8	1286	.10904	777.8	1411	.14942	708.9
23	415.48	1603	.20496	623.8	1405	.14766	711.7	1542	.18804	648.6
24	452.39	1746	.24192	572.9	1530	.18463	653.7	1679	.22500	595.7
25	490.87	.001894	$\bar{3}.27738$	528.0	.001660	$\bar{3}.22008$	602.4	.001822	$\bar{3}.26046$	549.0
26	530.93	2046	.31146	488.1	1795	.25415	557.0	1970	.29453	507.5
27	572.56	2209	.34423	452.6	1936	.28693	516.5	2125	.32731	470.6
28	615.75	2376	.37583	420.9	2082	.31852	480.3	2285	.35890	437.6
29	660.52	2549	.40630	392.4	2234	.34900	447.7	2451	.38938	408.0
30	706.82	.002727	$\bar{3}.43575$	366.7	.002390	$\bar{3}.37845$	418.4	.002623	$\bar{3}.41882$	381.2
31	754.77	2912	.46424	343.4	2552	.40693	391.8	2801	.44731	357.0
32	804.25	3103	.49181	322.2	2720	.43450	367.7	2985	.47488	335.1
33	855.30	3300	.51854	303.0	2892	.46123	345.8	3174	.50161	315.1
34	907.92	3503	.54446	285.4	3070	.48716	325.7	3369	.52754	296.8
35	962.11	.003712	$\bar{3}.56964$	269.4	.003253	$\bar{3}.51233$	307.4	.003570	$\bar{3}.55271$	280.1
36	1017.88	4927	.59412	254.6	3442	.53681	290.5	3777	.57719	264.7
37	1075.21	4149	.61791	241.0	3636	.56061	275.0	3990	.60098	250.6
38	1134.11	4376	.64108	228.5	3844	.58476	260.2	4218	.62514	237.1
39	1194.59	4609	.66364	216.9	4040	.60633	247.6	4433	.64671	225.6
40	1256.64	.004849	$\bar{3}.68563$	206.2	.004249	$\bar{3}.62833$	235.3	.004664	$\bar{3}.66871$	214.4
41	1320.25	5094	.70708	196.3	4465	.64977	224.0	4900	.69015	204.1
42	1385.44	5346	.72801	187.1	4685	.67070	213.5	5141	.71108	194.5
43	1452.20	5603	.74845	178.5	4911	.69114	203.6	5389	.73152	185.6
44	1520.53	5867	.76842	170.4	5142	.71111	194.5	5643	.75149	177.2
45	1590.43	.006137	$\bar{3}.78793$	162.9	.005378	$\bar{3}.73063$	185.9	.005902	$\bar{3}.77101$	169.4
46	1661.90	6412	.80703	155.9	5620	.74972	177.9	6167	.79010	162.1
47	1734.94	6694	.82569	149.4	5867	.76840	170.5	6438	.80878	155.3
48	1809.56	6982	.84399	143.2	6119	.78669	163.4	6715	.82706	148.9
49	1885.74	7276	.86289	137.4	6377	.80459	156.8	6998	.84497	142.9
50	1963.50	.007576	$\bar{3}.87945$	132.0	.006640	$\bar{3}.82214$	150.6	.007287	$\bar{3}.86252$	137.2
51	2042.82	7882	.89664	126.9	6908	.83934	144.8	7581	.87972	131.9
52	2123.72	8194	.91352	122.0	7181	.85621	139.2	7881	.89659	126.9
53	2206.18	8512	.93005	117.5	7460	.87275	134.0	8187	.91313	122.1
54	2290.22	8837	.94630	113.2	7744	.88899	129.1	8499	.92937	117.7
55	2375.83	.009167	$\bar{3}.96223$	109.1	.008034	$\bar{3}.90493$	124.5	.0088817	$\bar{3}.94531$	113.4

BRITISH UNITS.

Cross sections and weights of wires.

Diam. in Mils.	Area of cross section in Sq. Mils.	Copper — Density 8.90.			Iron — Density 7.80.			Brass — Density 8.56.		
		Pounds per Foot.	Log.	Feet per Pound.	Pounds per Foot.	Log.	Feet per Pound.	Pounds per Foot.	Log.	Feet per Pound.
55	2375.83	.009167	$\bar{3}.96223$	109.1	.008034	$\bar{3}.90493$	124.5	.008817	$\bar{3}.94531$	113.4
56	2463.01	09504	.97789	105.2	08329	.92058	120.1	09140	.96096	109.4
57	2551.76	09846	.99325	101.6	08629	.93595	115.9	09470	.97633	105.6
58	2642.08	10195	$\bar{2}.00837$	98.1	08934	.95106	111.9	09805	.99144	102.0
59	2733.97	10549	.02320	94.8	09245	.96591	108.2	10146	$\bar{2}.00629$	98.6
60	2827.43	.01091	$\bar{2}.03782$	91.66	.00956	$\bar{3}.98050$	104.59	.01049	$\bar{2}.02088$	95.30
61	2922.47	1128	.05216	88.68	0988	.99486	101.19	1085	.03524	92.21
62	3019.07	1165	.06628	85.84	1021	$\bar{2}.00898$	97.95	1120	.04936	89.25
63	3117.25	1203	.08019	83.14	1054	.02288	94.87	1157	.06326	86.45
64	3216.99	1241	.09386	80.56	1088	.03656	91.83	1194	.07694	83.77
65	3318.31	.01280	$\bar{2}.10732$	78.11	.01122	$\bar{2}.05003$	89.12	.01231	$\bar{2}.09041$	81.21
66	3421.19	1320	.12061	75.76	1157	.06329	86.44	1270	.10367	78.76
67	3525.65	1360	.13367	73.51	1192	.07635	83.88	1308	.11673	76.43
68	3631.68	1401	.14655	71.36	1228	.08922	81.42	1348	.12960	74.20
69	3739.28	1443	.15924	69.30	1264	.10190	79.09	1388	.14228	72.06
70	3848.45	.01485	$\bar{2}.17174$	67.34	.01302	$\bar{2}.11451$	76.82	.01429	$\bar{2}.15489$	70.00
71	3959.19	1528	.18404	65.46	1339	.12672	74.69	1469	.16710	68.06
72	4071.50	1571	.19618	63.65	1377	.13887	72.63	1511	.17925	66.19
73	4185.39	1615	.20817	61.92	1415	.15085	70.66	1553	.19123	64.38
74	4300.84	1660	.22000	60.26	1454	.16267	68.76	1596	.20304	62.66
75	4417.86	.01705	$\bar{2}.23165$	58.66	.01494	$\bar{2}.17432$	66.95	.01639	$\bar{2}.21460$	61.01
76	4536.46	1751	.24317	57.13	1534	.18583	65.19	1684	.22621	59.40
77	4656.63	1797	.25453	55.65	1575	.19718	63.50	1728	.23756	57.87
78	4778.36	1844	.26574	54.23	1616	.20839	61.89	1773	.24877	56.39
79	4901.67	1892	.27681	52.87	1658	.21946	60.33	1819	.25974	54.99
80	5026.55	.01939	$\bar{2}.28769$	51.56	.01700	$\bar{2}.23038$	58.83	.01865	$\bar{2}.27076$	53.61
81	5153.00	1988	.29848	50.29	1743	.24117	57.39	1912	.28155	52.29
82	5281.02	2038	.30914	49.07	1786	.25183	56.00	1960	.29221	51.03
83	5410.61	2088	.31966	47.90	1830	.26236	54.66	2008	.30274	49.80
84	5541.77	2138	.33006	46.77	1874	.27276	53.36	2057	.31314	48.63
85	5674.50	.02189	$\bar{2}.34034$	45.67	.01919	$\bar{2}.28304$	52.11	.02106	$\bar{2}.32342$	47.49
86	5808.80	2241	.35050	44.62	1964	.29320	50.91	2156	.33358	46.39
87	5944.68	2294	.36054	43.60	2010	.30324	49.75	2206	.34362	45.33
88	6082.12	2347	.37047	42.61	2057	.31317	48.62	2257	.35355	44.30
89	6221.14	2400	.38028	41.66	2104	.32298	47.54	2309	.36336	43.31
90	6361.73	.02455	$\bar{2}.38999$	40.74	.02151	$\bar{2}.33269$	46.49	.02360	$\bar{2}.37297$	42.37
91	6503.88	2509	.39958	39.85	2199	.34228	45.47	2414	.38266	41.43
92	6647.61	2565	.40908	38.99	2248	.35178	44.49	2467	.39216	40.54
93	6792.91	2621	.41847	38.15	2297	.36116	43.54	2521	.40154	39.67
94	6939.78	2678	.42775	37.35	2347	.37046	42.61	2575	.41084	38.83
95	7088.22	.02735	$\bar{2}.43694$	36.56	.02397	$\bar{2}.37965$	41.72	.02630	$\bar{2}.42003$	38.02
96	7238.23	2793	.44604	35.81	2448	.38874	40.86	2686	.42912	37.37
97	7389.81	2851	.45404	35.07	2499	.39775	40.02	2742	.43812	36.46
98	7542.96	2910	.46395	34.36	2551	.40665	39.20	2799	.44703	35.72
99	7697.69	2970	.47277	33.67	2603	.41547	38.42	2857	.45585	35.01
100	7853.98	.03030	$\bar{2}.48150$	33.00	.02656	$\bar{2}.42420$	37.65	.02915	$\bar{2}.46458$	34.31

METRIC UNITS.

Cross sections and weights of wires.

This table gives the cross section and the weight in metric units of copper, iron, and brass wires of the diameters given in the first column. For one tenth the diameter divide sections and weights by 100. For ten times the diameter multiply by 100, and so on.

Diam. in thousandths of a cm.	Area of cross section.	Copper — Density 8.90.			Iron — Density 7.80.			Brass — Density 8.56.		
		Grammes per Metre.	Log.	Metres per Gramme.	Grammes per Metre.	Log.	Metres per Gramme.	Grammes per Metre.	Log.	Metres per Gramme.
10	78.54	0.06990	$\bar{2}$.84448	14.306	0.06126	$\bar{2}$.78718	16.324	0.06723	$\bar{2}$.82756	14.874
11	95.03	.08458	.92725	11.823	.07412	.86996	13.492	.08135	.91034	12.293
12	113.10	.10065	$\bar{1}$.00285	9.935	.08822	.94556	11.335	.09681	.98594	10.330
13	132.73	.11813	.07236	8.465	.10353	$\bar{1}$.01506	9.659	.11362	$\bar{1}$.05544	8.801
14	153.94	.13701	.13674	7.299	.12008	.07945	8.328	.13177	.11983	7.589
15	176.71	0.1573	$\bar{1}$.19665	6.358	0.1378	$\bar{1}$.13936	7.255	0.1513	$\bar{1}$.17974	6.611
16	201.06	.1789	.25272	5.588	.1568	.19542	6.376	.1721	.23580	5.810
17	226.98	.2020	.30538	4.951	.1770	.24808	5.648	.1943	.28846	5.147
18	254.47	.2265	.35503	4.415	.1985	.29773	5.038	.2178	.33811	4.591
19	283.53	.2523	.40199	3.963	.2212	.34469	4.522	.2427	.38507	4.120
20	314.16	0.2796	$\bar{1}$.44654	3.577	0.2450	$\bar{1}$.38925	4.081	0.2689	$\bar{1}$.42963	3.719
21	346.36	.3083	.48892	.244	.2702	.43162	3.701	.2965	.47200	.373
22	380.13	.3383	.52932	2.956	.2965	.47203	.373	.3254	.51241	.073
23	415.48	.3698	.56794	.704	.3241	.51064	.086	.3557	.55103	2.812
24	452.39	.4026	.60490	.484	.3529	.54761	2.834	.3872	.58799	.582
25	490.87	0.4369	$\bar{1}$.64036	2.289	0.3829	$\bar{1}$.58306	2.612	0.4202	$\bar{1}$.62344	2.380
26	530.93	.4725	.67443	.116	.4141	.61713	.415	.4545	.65751	.200
27	572.56	.5096	.70721	1.962	.4466	.64992	.239	.4901	.69030	.040
28	615.75	.5480	.73880	.825	.4803	.68150	.082	.5271	.72188	1.897
29	660.52	.5879	.76928	.701	.5152	.71198	1.941	.5654	.75236	.769
30	706.86	0.6291	$\bar{1}$.79872	1.590	0.5514	$\bar{1}$.74143	1.814	0.6051	$\bar{1}$.78181	1.653
31	754.77	.6717	.82721	.489	.5887	.76991	.699	.6461	.81029	.548
32	804.25	.7158	.85478	.397	.6273	.79749	.594	.6884	.83787	.453
33	855.30	.7612	.88151	.314	.6671	.82421	.499	.7321	.86459	.366
34	907.92	.8081	.90744	.238	.7082	.85014	.412	.7772	.89052	.287
35	962.11	0.856	$\bar{1}$.93261	1.168	0.7504	$\bar{1}$.87531	1.333	0.8236	$\bar{1}$.91570	1.214
36	1017.88	.906	.95709	.104	.7939	.89979	.260	.8713	.94017	.148
37	1075.21	.957	.98088	.045	.8387	.92359	.192	.9204	.96397	.087
38	1134.11	1.012	0.00504	0.988	.8866	.94775	.128	.9730	.98813	.028
39	1194.59	.063	.02661	.941	.9318	.96931	.073	1.0230	0.00969	0.978
40	1256.64	1.118	0.04861	0.8941	0.980	$\bar{1}$.99131	1.0200	1.076	0.03169	0.9296
41	1320.25	.175	.07005	.8511	1.030	0.01275	0.9711	.130	.05313	.8849
42	1385.44	.233	.09098	.8110	.081	.03368	.9254	.186	.07406	.8432
43	1452.20	.292	.11142	.7738	.133	.05412	.8828	.243	.09450	.8044
44	1520.53	.353	.13139	.7389	.186	.07409	.8432	.302	.11447	.7683
45	1590.43	1.415	0.15091	0.7065	1.241	0.09361	0.8061	1.361	0.13399	0.7345
46	1661.90	.479	.17000	.6761	.296	.11270	.7714	.423	.15308	.7029
47	1734.94	.544	.18868	.6476	.353	.13138	.7389	.485	.17176	.6734
48	1809.56	.611	.20696	.6209	.411	.14967	.7085	.549	.19005	.6456
49	1885.74	.678	.22487	.5958	.471	.16758	.6799	.614	.20796	.6195
50	1963.50	1.748	0.24242	0.5722	1.532	0.18513	0.6530	1.681	0.22551	0.5950
51	2042.82	.818	.25962	.5500	.593	.20232	.6276	.753	.24371	.5705
52	2123.72	.890	.27649	.5291	.657	.21919	.6037	.818	.25957	.5501
53	2206.18	.964	.29303	.5093	.721	.23574	.5811	.888	.27612	.5295
54	2290.22	2.038	.30927	.4906	.786	.25197	.5598	.960	.29235	.5101
55	2375.83	2.114	0.32521	0.4729	1.853	0.26791	0.5396	2.034	0.30829	0.4917

METRIC UNITS.

Cross sections and weights of wires.

Diam. in thousandths of a cm.	Area of cross section.	Copper — Density 8.90. Grammes per Metre.	Log.	Metres per Gramme.	Iron — Density 7.80. Grammes per Metre.	Log.	Metres per Gramme.	Brass — Density 8.56. Grammes per Metre.	Log.	Metres per Gramme.
55	2375.83	2.114	0.32521	.4729	1.853	0.26791	.5396	2.034	0.30829	.4917
56	2463.01	.192	.34086	.4562	.921	.28356	.5205	.108	.32394	.4743
57	2551.76	.271	.35623	.4403	.990	.29893	.5024	.184	.33931	.4578
58	2642.08	.351	.37134	.4253	2.061	.31404	.4852	.262	.35442	.4422
59	2733.97	.433	.38618	.4112	.132	.32889	.4689	.340	.36927	.4273
60	2827.43	2.516	0.40078	.3974	2.205	0.34349	.4534	2.420	0.38387	.4132
61	2922.47	.601	.41514	.3845	.280	.35784	.4387	.502	.39823	.3997
62	3019.07	.687	.42926	.3722	.355	.37196	.4246	.584	.41235	.3869
63	3117.25	.774	.44316	.3604	.431	.38587	.4113	.668	.42625	.3748
64	3216.99	.863	.45684	.3493	.509	.39954	.3985	.760	.44092	.3623
65	3318.31	2.953	0.47031	.3386	2.588	0.41301	.3864	2.840	0.45339	.3521
66	3421.19	3.045	.48357	.3284	.669	.42627	.3747	.929	.46665	.3415
67	3525.65	.138	.49663	.3187	.750	.43933	.3636	3.018	.47971	.3313
68	3631.68	.232	.50950	.3094	.833	.45220	.3530	.109	.49258	.3217
69	3739.28	.328	.52218	.3005	.917	.46488	.3429	.201	.50526	.3124
70	3848.45	3.426	0.53479	.2919	3.003	0.47749	.3330	3.295	0.51787	.3035
71	3959.19	.524	.54700	.2838	.088	.48970	.3238	.389	.53008	.2951
72	4071.50	.624	.55915	.2759	.176	.50185	.3149	.485	.54223	.2869
73	4185.39	.725	.57113	.2685	.265	.51383	.3063	.583	.55421	.2791
74	4300.84	.828	.58294	.2612	.355	.52565	.2981	.682	.56603	.2716
75	4417.86	3.932	0.59460	.2543	3.446	0.53731	.2902	3.782	0.57769	.2644
76	4536.46	4.037	.60611	.2477	.538	.54881	.2826	.883	.58919	.2575
77	4656.63	.144	.61746	.2413	.632	.56017	.2753	.986	.60056	.2509
78	4778.36	.253	.62867	.2351	.727	.57137	.2683	4.090	.61175	.2445
79	4901.67	.362	.63974	.2292	.823	.58244	.2615	.177	.62283	.2394
80	5026.55	4.474	0.65066	.2235	3.921	0.59336	.2550	4.303	0.63375	.2324
81	5153.00	.586	.66145	.2180	4.019	.60415	.2488	.411	.64454	.2267
82	5281.02	.700	.67211	.2128	.119	.61481	.2428	.521	.65519	.2212
83	5410.61	.815	.68264	.2077	.220	.62534	.2369	.631	.66572	.2159
84	5541.77	.932	.69304	.2027	.323	.63574	.2313	.744	.67612	.2108
85	5674.50	5.050	0.70332	.1980	4.426	0.64602	.2259	4.857	0.68640	.2059
86	5808.80	.170	.71348	.1934	.531	.65618	.2207	.972	.69656	.2011
87	5944.68	.291	.72352	.1890	.637	.66622	.2157	5.089	.70660	.1965
88	6082.12	.413	.73345	.1847	.744	.67615	.2108	.206	.71653	.1921
89	6221.14	.537	.74326	.1806	.852	.68596	.2061	.325	.72634	.1878
90	6361.73	5.662	0.75297	.1766	4.962	0.69567	.2015	5.446	0.73605	.1836
91	6503.88	.788	.76256	.1728	5.073	.70527	.1971	.567	.74565	.1796
92	6647.61	.916	.77206	.1690	.185	.71476	.1929	.690	.75514	.1757
93	6792.91	6.046	.78144	.1654	.298	.72414	.1887	.815	.76452	.1720
94	6939.78	.176	.79074	.1619	.413	.73344	.1847	.940	.77382	.1683
95	7088.22	6.309	0.79993	.1585	5.529	0.74263	.1809	6.068	0.78301	.1648
96	7238.23	.442	.80902	.1552	.646	.75173	.1771	.196	.79211	.1614
97	7389.81	.577	.81802	.1520	.764	.76073	.1735	.326	.80111	.1581
98	7542.96	.713	.82693	.1490	.884	.76964	.1670	.457	.81002	.1549
99	7697.69	.851	.83575	.1460	6.004	.77846	.1665	.589	.81884	.1518
100	7853.98	6.990	0.84448	.1431	6.126	0.78718	.1632	6.723	0.82756	.1487

BRITISH AND METRIC UNITS.

Cross sections and weights of wires.

The cross section and the weight, in different units, of Aluminium wire of the diameters given in the first column. For one tenth the diameter divide sections and weights by 100. For ten times the diameter multiply by 100, and so on.

Diam. in Mils.	Area of cross section in Sq. Mils.	Aluminium — Density 2.67. Pounds per Foot.	Log.	Feet per Pound.	Ounces per Foot.	Log.	Feet per Ounce.	Grammes per Metre.*	Log.	Metres per Gramme.
10	78.54	.0000909	$\bar{5}.95862$	11000.	.001455	$\bar{3}.16274$	687.5	.02097	$\bar{2}.32160$	47.69
11	95.03	01100	4.04139	9091.	01760	.24551	602.4	.02537	.40437	39.41
12	113.10	01309	.11699	7638.	02095	.32111	477.4	.03020	.47997	33.11
13	132.73	01536	.18650	6509.	02458	.39062	406.8	.03544	.54948	28.22
14	153.94	01782	.25088	5612.	02851	.45500	350.8	.04110	.61386	24.33
15	176.71	.0002045	$\bar{4}.31079$	4889.	.003273	$\bar{3}.51491$	305.6	.04718	$\bar{2}.67377$	21.19
16	201.06	02327	.36685	4297.	03724	.57097	268.5	.05368	.72984	18.63
17	226.98	02627	.41952	3876.	04204	.62364	237.9	.06060	.78250	16.50
18	254.47	02946	.46917	3395.	04713	.67329	212.2	.06794	.83215	14.72
19	283.53	03282	.51613	3047.	05251	.72025	190.4	.07570	.87911	13.21
20	314.16	.0003636	$\bar{4}.56068$	2750.	.005818	$\bar{3}.76480$	171.9	.08388	$\bar{2}.92366$	11.922
21	346.36	04009	.60306	2494.	06415	.80718	155.9	.09248	.96604	10.813
22	380.13	04400	.64346	2273.	07040	.84758	142.0	.10149	$\bar{1}.00644$	9.853
23	415.48	04809	.68208	2079.	07697	.88630	129.9	.11093	.04506	9.014
24	452.39	05237	.71904	1910.	08378	.92316	119.4	.12079	.08202	8.279
25	490.87	.0005682	$\bar{4}.75450$	1760.	.00909	$\bar{3}.95862$	110.00	.1311	$\bar{1}.11748$	7.630
26	530.93	06147	.78867	1627.	0983	.99269	101.70	.1418	.15155	7.054
27	572.56	06628	.82135	1509.	1060	$\bar{2}.02547$	94.30	.1529	.18433	6.541
28	615.75	07127	.85293	1403.	1140	.05705	87.69	.1644	.21592	6.083
29	660.52	07646	.88341	1308.	1223	.08753	81.75	.1764	.24640	5.670
30	706.86	.0008182	$\bar{4}.91286$	1222.	.01309	$\bar{2}.11698$	76.39	.1887	$\bar{1}.27584$	5.299
31	754.77	08737	.94134	1145.	1398	.14546	71.54	.2015	.30433	4.962
32	804.25	09309	.96892	1074.	1489	.17304	66.89	.2147	.33190	.657
33	855.30	09900	.99565	1010.	1584	.19977	63.13	.2284	.35863	.379
34	907.92	10509	$\bar{3}.02158$	952.	1681	.22570	59.47	.2424	.38456	.125
35	962.11	.001114	$\bar{3}.04675$	897.9	.01782	$\bar{2}.25087$	56.12	.2569	$\bar{1}.40973$	3.893
36	1017.88	1178	.07123	848.8	1885	.27535	53.05	.2718	.43421	.680
37	1075.21	1245	.09502	803.5	1991	.29914	50.22	.2871	.45800	.483
38	1134.11	1316	.11918	760.0	2105	.32329	47.50	.3035	.48216	.295
39	1194.59	1383	.14075	723.2	2212	.34487	45.20	.3190	.50373	.135
40	1256.64	.001455	$\bar{3}.16275$	687.5	.02327	$\bar{2}.36687$	42.97	.3355	$\bar{1}.52573$	2.980
41	1320.25	1528	.18419	654.4	2445	.38831	40.90	.3525	.54717	.837
42	1385.44	1604	.20512	623.6	2566	.40924	38.97	.3699	.56810	.704
43	1452.20	1681	.22556	594.9	2690	.42968	37.18	.3877	.58854	.579
44	1520.53	1760	.24552	568.2	2816	.44964	35.51	.4060	.60851	.463
45	1590.43	.001841	$\bar{3}.26504$	543.2	.02946	$\bar{2}.46916$	33.95	.4246	$\bar{1}.62803$	2.355
46	1661.90	1924	.28413	519.8	3078	.48825	32.49	.4437	.64712	.254
47	1734.94	2008	.30281	498.0	3213	.50693	31.12	.4632	.66580	.159
48	1809.56	2095	.32110	477.4	3351	.52522	29.84	.4832	.68408	.070
49	1885.74	2183	.33901	458.1	3492	.54313	28.63	.5035	.70199	1.986
50	1963.50	.002273	$\bar{3}.35656$	440.0	.03636	$\bar{2}.56068$	27.50	.5243	$\bar{1}.71954$	1.907
51	2042.82	2365	.37376	422.9	3783	.57788	26.43	.5454	.73674	.833
52	2123.72	2458	.39063	406.8	3933	.59475	25.42	.5670	.75361	.764
53	2206.18	2554	.40717	394.2	4086	.61129	24.47	.5891	.77015	.698
54	2290.22	2651	.42341	377.2	4242	.62753	23.57	.6115	.78639	.635
55	2375.83	.002750	$\bar{3}.43934$	363.6	.04400	$\bar{2}.64346$	22.73	.6343	$\bar{1}.80233$	1.576

* Diameters and sections in terms of thousandths of a centimetre.

BRITISH AND METRIC UNITS.

Cross sections and weights of wires.

Diam. in Mils.	Area of cross section in Sq. Mils.	Aluminium — Density 2.67. Pounds per Foot.	Log.	Feet per Pound.	Ounces per Foot.	Log.	Feet per Ounce.	Grammes per Metre.*	Log.	Metres per Gramme.
55	2375.83	.002750	$\bar{3}.43934$	363.6	.04400	$\bar{2}.64346$	22.73	0.6343	$\bar{1}.80233$	1.576
56	2463.01	2851	.45500	350.8	.04562	.65912	21.92	.6576	.81798	.521
57	2551.76	2954	.47037	338.6	.04726	.67449	21.16	.6813	.83335	.468
58	2642.08	3058	.48547	327.0	.04893	.68959	20.44	.7054	.84846	.418
59	2733.97	3165	.50032	316.0	.05063	.70444	19.75	.7300	.86331	.370
60	2827.43	.003273	$\bar{3}.51492$	305.5	.05236	$\bar{2}.71904$	19.10	0.7549	$\bar{1}.87790$	1.325
61	2922.47	3383	.52928	295.6	.05413	.73340	18.48	.7803	.89226	.282
62	3019.07	3495	.54340	286.2	.05591	.74752	17.88	.8061	.90638	.241
63	3117.25	3608	.55730	277.1	.05773	.76142	17.32	.8323	.92028	.201
64	3216.99	3724	.57098	268.5	.05958	.77510	16.78	8589	.93396	.164
65	3318.31	.003841	$\bar{3}.58445$	260.3	.06146	$\bar{2}.78857$	16.27	0.8860	$\bar{1}.94743$	1.129
66	3421.19	3960	.59771	252.5	.06336	.80183	15.78	.9135	.96069	.095
67	3525.65	4081	.61077	245.0	.06530	.81489	15.31	.9413	.97375	.062
68	3631.68	4204	.62364	237.9	.06726	.82777	14.87	.9697	.98662	.031
69	3739.28	4328	.63632	231.0	.06925	.84044	14.44	.9984	.99930	.002
70	3848.45	.004456	$\bar{3}.64893$	224.4	.07129	$\bar{2}.85305$	14.03	1.028	0.01191	0.9730
71	3959.19	4583	.66114	218.2	.07333	.86526	13.64	.057	.02412	.9460
72	4071.50	4713	.67328	212.2	.07541	.87740	13.26	.087	.03627	.9199
73	4185.39	4845	.68526	206.4	.07751	.88938	12.90	.117	.04825	.8949
74	4300.84	4978	.69708	200.9	.07965	.90120	12.55	.148	.06006	.8708
75	4417.86	.005114	$\bar{3}.70874$	195.5	.08182	$\bar{2}.91286$	12.22	1.180	0.07172	0.8477
76	4536.46	5251	.72025	190.4	.08402	.92437	11.90	.211	.08323	.8256
77	4656.63	5390	.73160	185.5	.08624	.93572	11.60	.243	.09458	.8043
78	4778.36	5531	.74281	180.8	.08850	.94693	11.30	.276	.10579	.7838
79	4901.67	5674	.75387	176.2	.09078	.95799	11.02	.309	.11686	.7641
80	5026.55	.005818	$\bar{3}.76480$	171.9	.09309	$\bar{2}.96892$	10.742	1.342	0.12778	0.7451
81	5153.00	5965	.77559	167.6	.09544	.97971	10.479	.376	.13857	.7268
82	5281.02	6113	.78625	163.6	.09781	.99037	10.224	.410	.14923	.7092
83	5410.61	6263	.79678	159.7	.10021	$\bar{1}.00090$	9.979	.445	.15976	.6922
84	5541.77	6415	.80718	155.9	.10264	.01130	9.743	.480	.17016	.6757
85	5674.50	.006568	$\bar{3}.81746$	152.2	.1051	$\bar{1}.02158$	9.515	1.515	0.18044	0.6600
86	5808.80	6724	.82762	148.7	.1076	.03174	9.295	.551	.19060	.6448
87	5944.68	6881	.83766	145.3	.1101	.04178	9.082	.587	.20064	.6300
88	6082.12	7040	.84758	142.0	.1126	.05170	8.878	.624	.21057	.6158
89	6221.14	7201	.85740	138.9	.1152	.06152	8.679	.661	.22038	.6020
90	6361.73	.007364	$\bar{3}.86710$	135.8	.1178	$\bar{1}.07122$	8.488	1.699	0.23009	0.5887
91	6503.88	7528	.87670	132.8	.1205	.08082	8.302	.737	.23968	.5759
92	6647.61	7695	.88619	130.0	.1231	.09031	8.122	.775	.24918	.5634
93	6792.91	7863	.89558	127.2	.1258	.09970	7.949	.814	.25856	.5514
94	6939.78	8033	.90487	124.5	.1285	.10899	7.780	.853	.26786	.5397
95	7088.22	.008205	$\bar{3}.91407$	121.9	.1313	$\bar{1}.11819$	7.617	1.893	0.27705	0.5284
96	7238.23	8378	.92316	119.4	.1341	.12728	7.459	.933	.28614	.5174
97	7389.81	8554	.93216	116.9	.1369	.13628	7.307	.973	.29514	.5068
98	7542.96	8731	.94107	114.5	.1397	.14519	7.158	2.014	.30405	.4965
99	7697.69	8910	.94989	112.2	.1426	.15401	7.015	.055	.31287	.4865
100	7853.98	.009091	$\bar{3}.95862$	110.0	.1455	$\bar{1}.16274$	6.875	2.097	0.32160	0.4769

* Diameters and sections in terms of thousandths of a centimetre.

BRITISH AND METRIC UNITS.

Cross sections and weights of wires.

The cross section and the weight, in different units, of Platinum wire of the diameters given in the first column. For one tenth the diameters divide sections and weights by 100. For ten times the diameter multiply by 100, and so on.

Diam. in Mils.	Area of cross section in Sq. Mils.	Platinum — Density 21.50. Pounds per Foot.	Log.	Feet per Pound.	Ounces per Foot.	Log.	Feet per Ounce.	Grammes per Metre.*	Log.	Metres per Gramme.
10	78.54	.0007321	$\bar{4}.86455$	1366.0	.01171	$\bar{2}.06867$	85.38	0.1689	$\bar{1}.22753$	5.922
1	95.03	008858	.94732	1129.0	.01417	.15144	70.56	.2043	.31030	4.894
12	113.10	01054	$\bar{3}.02292$	948.6	.01687	.22704	59.29	.2432	.38590	4.113
13	132.73	01237	.09243	808.3	.01979	.29655	50.52	.2854	.45541	3.504
14	153.94	01435	.15681	696.9	.02296	.36093	43.56	.3310	.51979	3.021
15	176.71	.001647	$\bar{3}.21672$	607.1	.02635	$\bar{2}.42084$	37.95	0.3799	$\bar{1}.57970$	2.632
16	201.06	01874	.27278	533.6	.03005	.47790	33.27	.4323	.63576	2.311
17	226.98	02116	.32544	472.7	.03385	.52956	29.54	.4880	.68843	2.049
18	254.47	02372	.37509	421.6	.03795	.57921	26.35	.5471	.73808	1.828
19	283.53	02643	.42206	378.4	.04228	.62618	23.65	.6096	.78504	1.640
20	314.16	.002928	$\bar{3}.46661$	341.5	.04685	$\bar{2}.67073$	21.34	0.6754	$\bar{1}.82959$	1.481
21	346.36	03228	.50898	309.7	.05165	.71310	19.36	.7447	.87197	.343
22	380.13	03543	.54939	282.2	.05669	.75351	17.64	.8173	.91237	.224
23	415.48	03873	.58801	258.2	.06196	.79213	16.14	.8933	.95099	.119
24	452.39	04217	.62497	237.2	.06747	.82909	14.82	.9726	.98795	.028
25	490.87	.004575	$\bar{3}.66042$	218.6	.07321	$\bar{2}.86454$	13.66	1.055	0.02341	0.9475
26	530.93	04949	.69449	202.1	.07918	.89861	12.63	.142	.05748	.8760
27	572.56	05324	.72628	187.8	.08539	.93140	11.71	.231	.09026	.8124
28	615.75	05739	.75886	174.2	.09183	.96298	10.89	.324	.12184	.7553
29	660.52	06157	.78934	162.4	.09851	.99346	10.15	.420	.15232	.7042
30	706.86	.006589	$\bar{3}.81879$	151.8	.1054	$\bar{1}.02291$	9.486	1.520	0.18177	0.6580
31	754.77	07035	.84727	142.1	.1126	.05139	8.884	.623	.21025	.6162
32	804.25	07496	.87485	133.4	.1199	.07897	8.338	.729	.23783	.5783
33	855.30	07972	.90157	125.4	.1276	.10569	7.840	.839	.26456	.5438
34	907.92	08463	.92750	118.2	.1354	.13162	7.385	.952	.29049	.5123
35	962.11	.008968	$\bar{3}.95268$	111.52	.1435	$\bar{1}.15680$	6.970	2.069	.031566	0.4834
36	1017.88	09488	.97715	105.41	.1518	.18127	6.588	.188	.34014	.4569
37	1075.21	10022	$\bar{2}.00095$	99.78	.1604	.20507	6.236	.312	.36393	.4326
38	1134.11	10595	.02511	94.38	.1695	.22923	5.899	.444	.38809	.4092
39	1194.59	11134	.04668	89.81	.1782	.25080	5.613	.568	.40966	.3893
40	1256.64	.01171	$\bar{2}.06867$	85.38	.1874	$\bar{1}.27279$	5.336	2.702	0.43166	0.3701
41	1320.25	1231	.09011	81.26	.1969	.29423	5.079	.839	.45309	.3523
42	1385.44	1291	.11104	77.44	.2066	.31516	4.840	.979	.47403	.3346
43	1452.20	1354	.13148	73.88	.2166	.33560	4.617	3.122	.49446	.3203
44	1520.53	1417	.15145	70.56	.2268	.35557	4.410	.269	.51443	.3059
45	1590.43	.01482	$\bar{2}.17097$	67.46	.2372	$\bar{1}.37509$	4.216	3.419	0.53395	0.2924
46	1661.90	1549	.19006	64.56	.2478	.39418	4.035	.573	.55304	.2799
47	1734.94	1617	.20874	61.84	.2587	.41286	3.865	.730	.57172	.2681
48	1809.56	1687	.22703	59.29	.2699	.43115	3.705	.891	.59001	.2570
49	1885.74	1758	.24494	56.89	.2812	.44906	3.556	4.054	.60792	.2467
50	1963.50	.01830	$\bar{2}.26249$	54.64	.2928	$\bar{1}.46661$	3.415	4.222	0.62547	0.2369
51	2042.82	1904	.27969	52.52	.3047	.48381	3.282	.392	.64267	.2277
52	2123.72	1979	.29655	50.52	.3167	.50067	3.157	.566	.65954	.2190
53	2206.18	2056	.31310	48.63	.3290	.51722	3.039	.743	.67608	.2108
54	2290.22	2135	.32933	46.84	.3415	.53345	2.928	.924	.69232	.2031
55	2375.83	.02214	$\bar{2}.34527$	45.16	.3543	$\bar{1}.54939$	2.822	5.108	0.70825	0.1958

* Diameters and sections in terms of thousandths of a centimetre.

BRITISH AND METRIC UNITS.

Cross sections and weights of wires.

Diam. in Mils.	Area of cross section in Sq. Mils.	Platinum — Density 21.50.								
		Pounds per Foot.	Log.	Feet per Pound.	Ounces per Foot.	Log.	Feet per Ounce.	Grammes per Metre.*	Log.	Metres per Gramme.
55	2375.83	.02214	$\bar{2}$.34527	45.16	0.3543	$\bar{1}$.54939	2.822	5.108	0.70825	.1958
56	2463.01	2296	.36092	43.56	.3673	.56504	.722	.295	.72390	.1888
57	2551.76	2378	.37630	42.04	.3806	.58042	.628	.486	.73928	.1823
58	2642.08	2463	.39140	40.61	.3940	.59552	.538	.680	.75438	.1760
59	2733.97	2548	.40625	39.24	.4077	.61037	.453	.878	.76923	.1701
60	2827.43	.02635	$\bar{2}$.42085	37.94	0.4217	$\bar{1}$.62497	2.372	6.079	0.78383	.1645
61	2922.47	2724	.43521	36.71	.4358	.63933	.294	.283	.79819	.1592
62	3019.07	2814	.44933	35.54	.4502	.65345	.221	.491	.81231	.1541
63	3117.25	2906	.46323	34.42	.4649	.66735	.151	.702	.82621	.1492
64	3216.99	2999	.47691	33.35	.4798	.68103	.084	.917	.83989	.1446
65	3318.31	.03093	$\bar{2}$.49037	32.33	0.4949	$\bar{1}$.69449	2.021	7.134	0.85336	.1402
66	3421.19	3189	.50363	31.36	.5102	.70775	1.960	.356	.86662	.1360
67	3525.65	3286	.51670	30.43	.5258	.72082	.902	.580	.87968	.1319
68	3631.68	3385	.52956	29.54	.5416	.73368	.846	.808	.89255	.1281
69	3739.28	3485	.54224	28.69	.5577	.74636	.793	8.039	.90523	.1244
70	3848.45	.03588	$\bar{2}$.55485	27.87	0.5741	$\bar{1}$.75897	1.742	8.276	0.91784	.1208
71	3959.19	3690	.56706	27.10	.5904	.77118	.694	.512	.93004	.1175
72	4071.50	3795	.57921	26.35	.6072	.78333	.647	.754	.94219	.1142
73	4185.39	3901	.59119	25.63	.6242	.79531	.602	.999	.95417	.1111
74	4300.84	4009	.60301	24.95	.6414	.80713	.559	9.247	.96599	.1081
75	4417.86	.04118	$\bar{2}$.61467	24.28	0.6589	$\bar{1}$.81879	1.518	9.498	0.97765	.10528
76	4536.46	4228	.62617	23.65	.6765	.83029	.478	9.753	.98916	.10253
77	4656.63	4340	.63753	23.04	.6945	.84165	.440	10.012	1.00051	.09988
78	4778.36	4454	.64874	22.45	.7126	.85286	.403	10.273	.01172	.09734
79	4901.67	4569	.65980	21.89	.7310	.86392	.368	10.539	.02278	.09489
80	5026.55	.04685	$\bar{2}$.67073	21.34	0.7496	$\bar{1}$.87485	1.334	10.81	1.03371	.09253
81	5153.00	4803	.68152	20.82	.7685	.88564	.301	11.08	.04450	.09026
82	5281.02	4922	.69217	20.32	.7876	.89629	.270	11.35	.05516	.08807
83	5410.61	5043	.70270	19.83	.8069	.90682	.239	11.63	.06568	.08596
84	5541.77	5165	.71310	19.36	.8265	.91722	.210	11.91	.07609	.08393
85	5674.50	.05289	$\bar{2}$.72338	18.91	0.8463	$\bar{1}$.92750	1.182	12.20	1.08637	.08197
86	5808.80	5414	.73354	18.47	.8663	.93766	.154	12.49	.09652	.08007
87	5944.68	5541	.74358	18.05	.8866	.94770	.128	12.78	.10657	.07807
88	6082.12	5669	.75351	17.64	.9070	.95763	.102	13.08	.11649	.07647
89	6221.14	5799	.76333	17.25	.9278	.96745	.078	13.37	.12631	.07477
90	6361.73	.05930	$\bar{2}$.77303	16.86	0.9487	$\bar{1}$.97715	1.0541	13.68	1.13601	.07311
91	6503.88	6062	.78263	16.50	.9699	.98675	.0310	13.98	.14561	.07152
92	6647.61	6196	.79212	16.14	.9914	.99624	.0087	14.29	.15510	.06997
93	6792.91	6332	.80151	15.79	1.0130	0.00563	0.9871	14.60	.16449	.06847
94	6939.78	6469	.81080	15.46	.0350	.01492	.9661	14.92	.17378	.06702
95	7088.22	.06607	$\bar{2}$.81999	15.14	1.057	0.02411	0.9460	15.24	1.18298	.06562
96	7238.23	6747	.82909	14.82	.079	.03321	.9264	15.56	.19207	.06426
97	7389.81	6888	.83809	14.52	.102	.04221	.9074	15.89	.20107	.06294
98	7542.96	7031	.84700	14.22	.125	.05112	.8890	16.22	.20998	.06166
99	7697.69	7175	.85582	13.94	.148	.05994	.8711	16.55	.21880	.06042
100	7853.98	.07321	$\bar{2}$.86455	13.66	1.171	0.06867	0.8538	16.89	1.22753	.05922

* Diameters and sections in terms of thousandths of a millimetre.

BRITISH AND METRIC UNITS.

Cross sections and weights of wires.

The cross section and the weight, in different units, of Gold wire of the diameters given in the first column. For one tenth the diameters divide sections and weights by 100. For ten times the diameter multiply by 100, and so on.

Diam. in Mils.	Area of cross section in Sq. Mils.	Gold — Density 19.30.								
		Troy Ounces per Foot.	Log.	Feet per Troy Ounce.	Grains per Foot.	Log.	Feet per Grain.	Grammes per Metre.*	Log.	Metres per Gramme.
10	78.54	.00958	$\bar{3}.98152$	104.35	4.600	0.66276	.2174	0.1516	$\bar{1}.18065$	6.597
11	95.03	.01160	2.06429	86.24	5.566	.74553	.1797	.1834	.26342	5.452
12	113.10	.01380	.13989	72.46	6.624	.82114	.1510	.2183	.33902	4.581
13	132.73	.01657	.21940	60.34	7.774	.89064	.1286	.2562	.40853	3.904
14	153.94	.01878	.27378	53.24	9.016	.95503	.1109	.2971	.47291	3.366
15	176.71	.02156	$\bar{2}.33369$	46.38	10.35	1.01493	.09662	0.3411	$\bar{1}.53282$	2.932
16	201.06	.02453	.38976	40.76	11.78	.07100	.08492	.3880	.58888	.577
17	226.98	.02770	.44242	36.11	13.29	.12366	.07522	.4381	.64154	.283
18	254.47	.03105	.49207	32.21	14.90	.17331	.06710	.4911	.69119	.036
19	283.53	.03460	.53903	28.90	16.61	.22027	.06022	.5472	.73816	1.827
20	314.16	.03833	$\bar{2}.58358$	26.09	18.40	1.26482	.05435	0.6063	$\bar{1}.78271$	1.649
21	346.36	.04226	.62596	23.66	20.29	.30720	.04939	.6685	.82509	.496
22	380.13	.04638	.66636	21.56	22.26	.34761	.04492	.7337	.86549	.363
23	415.48	.04954	.69498	20.18	24.33	.38622	.04109	.8019	.90411	.248
24	452.39	.05520	.74194	18.12	26.50	.42319	.03774	.8731	.94107	.145
25	490.87	.05990	$\bar{2}.77740$	16.70	28.75	1.45865	.03478	0.9474	$\bar{1}.97652$	1.0555
26	530.93	.06478	.81147	15.44	31.10	.49271	.03216	1.0247	0.01059	0.9759
27	572.56	.06986	.84425	14.31	33.53	.52549	.02982	.1050	.04338	9050
28	615.75	.07513	.87584	13.31	36.06	.55708	.02773	.1884	.07496	.8415
29	660.52	.08060	.90632	12.41	38.69	.58756	.02585	.2748	.10544	.7844
30	706.86	.08625	$\bar{2}.93577$	11.594	41.40	1.61701	.02415	1.364	0.13489	0.7330
31	754.77	.09210	.96425	10.858	44.21	.64549	.02262	.457	.16337	.6912
32	804.25	.09813	.99182	10.190	47.10	.67306	.02123	.552	.19095	.6442
33	855.30	.10436	$\bar{1}.01855$	9.582	50.09	.69979	.01996	.651	.21768	.6058
34	907.92	.11078	.04448	9.027	53.18	.72572	.01881	.752	.24360	.5707
35	962.11	.1174	$\bar{1}.06965$	8.518	56.35	1.75089	.01775	1.857	0.26878	0.5385
36	1017.88	.1242	.09413	8.051	59.62	.77537	.01677	.965	.29325	.5090
37	1075.21	.1312	.11792	7.622	62.97	.79917	.01588	2.070	.31605	.4830
38	1134.11	.1387	.14208	7.210	66.58	.82332	.01502	.194	.34121	.4558
39	1194.59	.1458	.16365	6.861	69.97	.84489	.01429	.306	.36278	.4337
40	1256.64	.1533	$\bar{1}.18565$	6.521	73.60	1.86689	.01359	2.425	0.38478	0.4123
41	1320.25	.1611	.20709	6.207	77.33	.88833	.01293	.548	.40621	.3924
42	1385.44	.1691	.22802	5.915	81.14	.90926	.01232	.674	.42715	.3740
43	1452.20	.1772	.24846	5.643	85.05	.92970	.01176	.803	.44758	.3568
44	1520.53	.1855	.26843	5.390	89.06	.94967	.01123	.935	.46755	.3408
45	1590.43	.1941	$\bar{1}.28795$	5.153	93.15	1.96919	.010735	3.070	0.48707	0.3258
46	1661.90	.2028	.30704	4.931	97.34	.98828	.010273	.207	.50616	.3118
47	1734.94	.2117	.32572	4.724	101.61	2.00696	.009842	.348	.52484	.2986
48	1809.56	.2208	.34400	4.529	105.99	.02525	.009435	.492	.54313	.2863
49	1885.74	.2301	.36191	4.346	110.45	.04315	.009054	.639	.56104	.2748
50	1963.50	.2396	$\bar{1}.37946$	4.174	115.0	2.06070	.008696	3.790	0.57859	0.2639
51	2042.82	.2493	.39666	4.012	119.6	.07790	.008358	.943	.59579	.2537
52	2123.72	.2591	.41353	3.859	124.4	.09477	.008039	4.099	.61265	.2440
53	2206.18	2692	.43007	3.715	129.2	.11131	.007739	.258	.62920	.2349
54	2290.22	.2795	.44631	3.578	134.1	.12755	.007455	.420	.64543	.2262
55	2375.83	.2899	$\bar{1}.46225$	3.449	139.2	2.14349	.007186	4.585	0.66137	0.2181

* Diameters and sections in terms of thousandths of a centimetre.

BRITISH AND METRIC UNITS.

Cross sections and weights of wires.

Diam. in Mils.	Area of cross section in Sq. Mils.	Gold — Density 19.30.								
		Troy Ounces per Foot.	Log.	Feet per Troy Ounce.	Grains per Foot.	Log.	Feet per Grain.	Grammes per Metre.*	Log.	Metres per Gramme.
55	2375.83	.2899	1̄.46225	3.449	139.2	2.14349	.007186	4.585	0.66137	.2181
56	2463.01	.3005	.47790	.327	144.3	.15914	6932	4.754	.67702	.2104
57	2551.76	.3114	.49327	.212	149.5	.17451	6691	4.925	.69240	.2031
58	2642.08	.3224	.50838	.102	154.7	.18962	6462	5.099	.70750	.1961
59	2733.97	.3336	.52323	2.998	160.1	.20447	6245	5.277	.72235	.1895
60	2827.43	.3450	1̄.53782	2.899	165.6	2.21906	.006039	5.457	0.73695	.1833
61	2922.47	.3566	.55218	.804	171.2	.23342	5842	5.640	.75131	.1773
62	3019.07	.3684	.56630	.715	176.8	.24754	5655	5.827	.76543	.1716
63	3117.25	.3804	.58020	.629	182.6	.26144	5477	6.016	.77933	.1662
64	3216.99	.3925	.59388	.548	188.4	.27512	5307	6.209	.79301	.1611
65	3318.31	.4049	1̄.60735	2.470	194.4	2.28859	.005145	6.404	0.80647	.1561
66	3421.19	.4175	.62061	.395	200.4	.30185	4991	6.603	.81973	.1514
67	3525.65	.4302	.63367	.324	206.5	.31491	4843	6.805	.83280	.1470
68	3631.68	.4431	.64654	.257	212.7	.32778	4701	7.010	.84566	.1427
69	3739.28	.4563	.65922	.192	219.0	.34046	4566	7.217	.85835	.1386
70	3848.45	.4697	1̄.67183	2.129	225.5	2.35307	.004435	7.429	0.87096	.1346
71	3959.19	.4831	.68404	.070	231.9	.36528	4312	7.641	.88316	.1309
72	4071.50	.4968	.69619	.013	238.4	.37743	4195	7.858	.89531	.1273
73	4185.39	.5107	.70817	1.958	245.1	.38941	4079	8.078	.90729	.1238
74	4300.84	.5248	.71998	.905	251.9	.40123	3970	8.301	.91911	.1204
75	4417.86	.5391	1̄.73164	1.855	258.8	2.41288	.003865	8.526	0.93077	.1173
76	4536.46	.5535	.74315	.807	265.7	.42439	3764	8.755	.94227	.1142
77	4656.63	.5682	.75450	.760	272.7	.43574	3666	8.987	.95363	.1113
78	4778.36	.5831	.76571	.715	279.9	.44695	3573	9.222	.96484	.1084
79	4901.67	.5981	.77678	.672	287.1	.45801	3483	9.460	.97590	.1057
80	5026.55	.6133	1̄.78770	1.630	294.4	2.46894	.003401	9.701	0.98683	.10308
81	5153.00	.6288	.79849	.590	301.8	.47973	3313	9.945	.99762	.10055
82	5281.02	.6444	.80915	.552	309.3	.49039	3233	10.192	1.00828	.09812
83	5410.61	.6602	.81968	.515	316.9	.50092	3156	10.442	.01880	.09577
84	5541.77	.6762	.83008	.479	324.6	.51132	3081	10.696	.02921	.09349
85	5674.50	.6924	1̄.84036	1.444	332.4	2.52160	.003009	10.95	1.03948	.09131
86	5808.80	.7088	.85052	.411	340.2	.53176	2939	11.21	.04964	.08919
87	5944.68	.7254	.86056	.379	348.2	.54180	2872	11.47	.05969	.08716
88	6082.12	.7421	.87049	.347	356.2	.55173	2807	11.74	.06961	.08519
89	6221.14	.7591	.88030	.317	364.4	.56154	2744	12.01	.07943	.08328
90	6361.73	.7763	1̄.89001	1.288	372.6	2.57125	.002684	12.28	1.08913	.08145
91	6503.88	.7936	.89960	.260	380.9	.58085	2625	12.55	.09873	.07967
92	6647.61	.8111	.90910	.233	389.3	.59034	2568	12.83	.10822	.07794
93	6792.91	.8291	.91858	.206	397.9	.59972	2513	13.11	.11761	.07628
94	6939.78	.8468	.92778	.181	406.5	.60902	2460	13.39	.12690	.07466
95	7088.22	.8649	1̄.93697	1.156	415.2	2.61821	.002409	13.68	1.13609	.07310
96	7238.23	.8832	.94606	.132	423.9	.62731	2359	13.97	.14519	.07158
97	7389.81	.9017	.95507	.109	432.8	.63631	2310	14.26	.15419	.07011
98	7542.96	.9204	.96397	.086	441.8	.64521	2263	14.56	.16310	.06869
99	7697.69	.9393	.97279	.065	450.9	.65403	2218	14.86	.17192	.06731
100	7853.98	.9583	1̄.98152	1.043	460.0	2.66276	.002174	15.16	1.18065	.06597

* Diameters and sections in terms of thousandths of a centimetre.

Table 62.

BRITISH AND METRIC UNITS.

Cross sections and weights of wires.

The cross section and the weight, in different units, of Silver wire of the diameters given in the first column. For one tenth the diameters divide the section and weights by 100. For ten times the diameter muliply by 100, and so on.

Diam. in Mils.	Area of cross section in Sq. Mils.	Silver — Density 10.50.								
		Troy Ounces per Foot.	Log.	Feet per Troy Ounce.	Grains per Foot.	Log.	Feet per Grain.	Grammes per Metre.*	Log.	Metres per Gramme.
10	78.54	.005214	$\bar{3}$.71715	191.79	2.503	0.39839	.3996	0.08247	$\bar{2}$.91628	12.126
11	95.03	.006308	.79992	158.52	3.028	.48117	.3302	.09978	.99905	10.022
12	113.10	.007508	.87553	133.19	3.604	.55677	.2775	.11876	$\bar{1}$.07465	8.420
13	132.73	.008811	.94503	113.49	4.229	.62627	.2364	.13937	.14416	7.175
14	153.94	.010219	$\bar{2}$.00942	97.86	4.905	.69066	.2039	.16164	.20854	6.186
15	176.71	.01173	$\bar{2}$.06932	85.24	5.631	0.75057	.1776	0.1855	$\bar{1}$.26845	5.389
16	201.06	.01335	.12539	74.92	6.407	.80663	.1561	.2111	.32452	4.737
17	226.98	.01507	.17805	66.37	7.233	.85929	.1383	.2383	.37718	4.196
18	254.47	.01689	.22770	59.20	8.109	.90894	.1233	.2672	.42683	3.743
19	283.53	.01882	.27466	53.13	9.034	.95590	.1107	.2977	.47379	3.359
20	314.16	.02086	$\bar{2}$.31921	47.95	10.01	1.00046	.09990	0.3299	$\bar{1}$.51834	3.031
21	346.36	.02299	.36159	43.49	11.04	.04283	.09060	.3637	.56072	2.750
22	380.13	.02523	.40200	39.63	12.11	.08324	.08256	.3991	.60112	.505
23	415.48	.02758	.44061	36.26	13.24	.12186	.07553	.4363	.63974	.292
24	452.39	.03003	.47758	32.99	14.42	.15882	.06937	.4750	.67670	.105
25	490.87	.03259	$\bar{2}$.51303	30.69	15.64	1.19427	.06425	0.5154	$\bar{1}$.71216	1.940
26	530.93	.03525	.54710	28.37	16.92	.22834	.05911	.5575	.74623	.794
27	572.56	.03801	.57988	26.31	18.24	.26113	.05481	.6012	.77901	.663
28	615.75	.04088	.61147	24.46	19.62	.29271	.05097	.6465	.81059	.547
29	660.52	.04385	.64195	22.81	21.05	.32319	.04751	.6935	.84108	.442
30	706.86	.04692	$\bar{2}$.67140	21.31	22.52	1.35264	.04440	0.7422	$\bar{1}$.87052	1.347
31	754.77	.05010	.69988	19.96	24.05	.38112	0.4158	.7925	.89900	.262
32	804.25	.05339	.72745	18.73	25.63	.40870	0.3902	.8445	.92658	.184
33	855.30	.05678	.75418	17.61	27.25	.43542	0.3669	.8981	.95331	.113
34	907.92	.06027	.78011	16.59	28.93	.46135	0.3457	.9533	.97924	.049
35	962.11	.06387	$\bar{2}$.80528	15.66	30.66	1.48653	.03262	1.010	0.00441	0.9899
36	1017.88	.06757	.82976	14.80	32.43	.51100	.03083	.069	.02889	.9356
37	1075.21	.07138	.85356	14.01	34.26	.53480	.02919	.129	.05268	.8857
38	1134.11	.07546	.87772	13.25	36.22	.55896	.02761	.194	.07684	.8378
39	1194.59	.07930	.89928	12.61	38.06	.58052	.02627	.254	.09841	.7973
40	1256.64	.08342	$\bar{2}$.92128	11.99	40.04	1.60252	.02497	1.319	0.12041	0.7579
41	1320.25	.08764	.94272	11.41	42.07	.62396	.02377	.386	.14185	.7213
42	1385.44	.09197	.96365	10.87	44.15	.64489	.02265	.455	.16278	.6874
43	1452.20	.09640	.98409	10.37	46.27	.66533	.02161	.525	.18322	.6558
44	1520.53	.10094	$\bar{1}$.00406	9.91	48.45	.68530	.02064	.597	.20318	.6263
45	1590.43	.1056	$\bar{1}$.02358	9.471	50.68	1.70482	.01973	1.670	0.22270	0.5988
46	1661.90	.1103	.04267	9.065	52.96	.72391	.01888	.745	.24179	.5731
47	1734.94	.1152	.06135	8.683	55.28	.74259	.01809	.822	.26047	.5489
48	1809.56	.1201	.07964	8.325	57.66	.76088	.01734	.900	.27876	.5263
49	1885.74	.1252	.09755	7.988	60.09	.77879	.01664	.980	.29667	.5050
50	1963.50	.1303	$\bar{1}$.11509	7.672	62.57	1.79634	.01598	2.062	0.31422	0.4850
51	2042.82	.1356	.13229	7.374	65.09	.81354	.01536	.145	.33142	.4662
52	2123.72	.1410	.14916	7.093	67.67	.83040	.01478	.230	.34829	.4484
53	2206.18	.1465	.16570	6.828	70.30	.84695	.01422	.316	.36483	.4317
54	2290.22	.1520	.18194	6.578	72.99	.86328	.01370	.405	.38107	.4158
55	2375.83	.1577	$\bar{1}$.19788	6.340	75.70	1.87912	.01321	2.495	0.39700	0.4009

* Diameters and sections in terms of thousandths of a centimetre.

BRITISH AND METRIC UNITS.

Cross sections and weights of wires.

Diam. in Mils.	Area of cross section in Sq. Mils.	Silver — Density 10.50. Troy Ounces per Foot.	Log.	Feet per Troy Ounce.	Grains per Foot.	Log.	Feet per Grain.	Grammes per Metre.*	Log.	Metres per Gramme.
55	2375.83	0.1577	$\bar{1}$.19788	6.340	75.70	1.87912	.01321	2.495	0.39700	0.4009
56	2463.01	.1635	.21353	.116	78.48	.89477	1274	.586	.41266	.3867
57	2551.76	.1694	.22890	5.903	81.31	.91014	1230	.679	.42803	.3732
58	2642.08	.1754	.24401	.701	84.19	.92525	1188	.774	.44314	.3605
59	2733.97	.1815	.25886	.510	87.12	.94010	1148	.871	.45798	.3484
60	2827.43	0.1877	$\bar{1}$.27346	5.328	90.09	1.95470	.01110	2.969	0.47258	0.3368
61	2922.47	.1940	.28781	.155	93.12	.96906	1074	3.069	.48694	.3259
62	3019.07	.2004	.30193	4.990	96.20	.98318	1040	.170	.50106	.3155
63	3117.25	.2069	.31584	.832	99.33	.99708	1007	.273	.51496	.3055
64	3216.99	.2136	.32951	.683	102.51	2.01075	0975	.378	.52864	.2961
65	3318.31	0.2203	$\bar{1}$.34298	4.540	105.7	2.02422	.009457	3.484	0.54211	0.2870
66	3421.19	.2271	.35624	.403	109.0	.03748	09173	.592	.55537	.2784
67	3525.65	.2340	.36930	.273	112.3	.05054	08903	.702	.56843	.2701
68	3631.68	.2411	.38217	.148	115.7	.06341	08642	.813	.58130	.2622
69	3739.28	.2482	.39485	.029	119.1	.07609	08393	.926	.59398	.2547
70	3848.45	0.2555	$\bar{1}$.40746	3.913	122.7	2.08870	.008153	4.042	0.60659	0.2474
71	3959.19	.2628	.41967	.805	126.2	.10091	07926	.157	.61880	.2406
72	4071.50	.2703	.43182	.700	129.7	.11306	07708	.275	.63094	.2339
73	4185.39	.2778	.44380	.599	133.4	.12504	07498	.395	.64293	.2275
74	4300.84	.2855	.45560	.502	137.0	.13686	07297	.516	.65474	.2214
75	4417.86	0.2933	$\bar{1}$.46728	3.410	140.8	2.14852	.007104	4.639	0.66640	0.2156
76	4536.46	.3011	.47878	.321	144.6	.16002	06918	.763	.67791	.2099
77	4656.63	.3091	.49014	.235	148.4	.17138	06739	.889	.68926	.2045
78	4778.36	.3172	.50134	.152	152.3	.18258	06568	5.017	.70047	.1993
79	4901.67	.3254	.51241	.073	156.2	.19365	06402	.147	.71153	.1943
80	5026.55	0.3337	$\bar{1}$.52333	2.997	160.2	2.20458	.006243	5.278	0.72246	0.1895
81	5153.00	.3421	.53412	.923	164.2	.21537	06090	.411	.73325	.1848
82	5281.02	.3506	.54478	.852	168.3	.22602	05942	.545	.74391	.1803
83	5410.61	.3592	.55531	.784	172.4	.23655	05800	.681	.75444	.1760
84	5541.77	.3679	.56571	.718	176.6	.24695	05663	.819	.76484	.1719
85	5674.50	0.3767	$\bar{1}$.57599	2.655	180.8	2.25723	.005531	5.958	0.77512	0.1678
86	5808.80	.3856	.58615	.593	185.1	.26739	05403	6.099	.78528	.1640
87	5944.68	.3946	.59619	.534	189.4	.27743	05279	.242	.79532	.1602
88	6082.12	.4038	.60612	.477	193.8	.28736	05160	.386	.80524	.1566
89	6221.14	.4130	.61593	.421	198.2	.29717	05045	.532	.81506	.1531
90	6361.73	0.4223	$\bar{1}$.62564	2.368	202.7	2.30688	.004933	6.680	0.82476	0.1497
91	6503.88	.4318	.63524	.316	207.2	.31648	04825	.829	.83436	.1464
92	6647.61	.4413	.64473	.266	211.8	.32597	04721	.980	.84385	.1433
93	6792.91	.4509	.65411	.218	216.4	.33535	04620	7.132	.85324	.1402
94	6939.78	.4607	.66341	.171	221.1	.34465	04522	.287	.86254	.1372
95	7088.22	0.4705	$\bar{1}$.67260	2.125	225.9	2.35384	.004428	7.443	0.87173	0.1344
96	7238.23	.4805	.68170	.081	230.6	.36294	04336	.600	.88082	.1316
97	7389.81	.4906	.69070	.038	235.5	.37194	04247	.759	.88982	.1289
98	7542.96	.5007	.69961	1.997	240.4	.38085	04161	.920	.89873	.1263
99	7697.69	.5110	.70842	.957	245.3	.38967	04077	8.083	.90755	.1237
100	7853.98	0.5214	$\bar{1}$.71715	1.918	250.3	2.39839	.003996	8.247	0.91628	0.1213

* Diameters and sections in terms of thousandths of a centimetre.

TABLE 63. — Weight of Sheet Metal. (Metric Measure.)

This table gives the weight in grammes of a plate one metre square and of the thickness stated in the first column.

Thickness in thousandths of a cm.	Iron.	Copper.	Brass.	Aluminium.	Platinum.	Gold.	Silver.
1	78.0	89.0	85.6	26.7	215.0	193.0	105.0
2	156.0	178.0	171.2	53.4	430.0	386.0	210.0
3	234.0	267.0	256.8	80.1	645.0	579.0	315.0
4	312.0	356.0	342.4	106.8	860.0	772.0	420.0
5	390.0	445.0	428.0	133.5	1075.0	965.0	525.0
6	468.0	534.0	513.6	160.2	1290.0	1158.0	630.0
7	546.0	623.0	599.2	186.9	1505.0	1351.0	735.0
8	624.0	712.0	684.8	213.6	1720.0	1544.0	840.0
9	702.0	801.0	770.4	240.3	1935.0	1737.0	945.0
10	780.0	890.0	856.0	267.0	2150.0	1930.0	1050.0

WEIGHT OF SHEET METAL.

TABLE 64.—Weight of Sheet Metal. (British Measure.)

Thickness in Mils.	Iron.	Copper.	Brass.	Aluminium.		Platinum.		Gold.*		Silver.*	
	Pounds per Sq. Foot.	Pounds per Sq. Foot.	Pounds per Sq. Foot.	Pounds per Sq. Foot.	Ounces per Sq. Foot.	Pounds per Sq. Foot.	Ounces per Sq. Foot.	Ounces per Sq. Foot.	Grains per Sq. Foot.	Ounces per Sq. Foot.	Grains per Sq. Foot.
1	.04058	.04630	.04454	.01389	.2222	.1119	1.790	1.4642	702.8	0.7967	382.4
2	.08116	.09260	.08908	.02778	.4445	.2237	3.579	2.9285	1405.7	1.5933	765.8
3	.12173	.13890	.13363	.04167	.6667	.3356	5.369	4.3927	2108.5	2.3900	1147.2
4	.16231	.18520	.17817	.05556	.8890	.4474	7.158	5.8570	2811.3	3.1867	1529.6
5	.20289	.23150	.22271	.06945	1.1112	.5593	8.948	7.3212	3514.2	3.9833	1912.0
6	.24347	.27780	.26725	.08334	1.3335	.6711	10.738	8.7854	4217.0	4.7800	2294.4
7	.28405	.32411	.31179	.09723	1.5557	.7830	12.527	10.2497	4919.8	5.5767	2676.8
8	.32463	.37041	.35634	.11112	1.7780	.8948	14.317	11.7139	5622.7	6.3734	3059.2
9	.36520	.41671	.40088	.12501	2.0002	1.0067	16.106	13.1782	6325.5	7.1700	3441.6
10	.40578	.46301	.44542	.13890	2.2224	1.1185	17.896	14.6424	7028.3	7.9667	3824.0

* Gold and silver are given in Troy ounces.

SIZE, WEIGHT, AND ELECTRICAL

Size, Weight, and Electrical Constants of pure hard drawn Copper Wire of different numbers

Size and Weight.

Gauge Number.	Diameter in Inches.	Square of Diameter (Circular Inches).	Section in Sq. Inches.	Pounds per Foot.	Log.	Feet per Pound.
0000	0.4600	0.2116	0.1662	0.6412	1̄.80701	1.560
000	.4096	.1678	.1318	.5085	.70631	1.967
00	.3648	.1331	.1045	.4033	.60560	2.480
0	.3249	.1055	.0829	.3198	.50489	3.127
1	0.2893	0.08369	0.06573	0.2536	1̄.40419	3.943
2	.2576	.06637	.05213	.2011	.30348	4.972
3	.2294	.05263	.04134	.1595	.20277	6.270
4	.2043	.04174	.03278	.1265	.10206	7.905
5	.1819	.03310	.02600	.1003	.00136	9.969
6	0.1620	0.02625	0.02062	0.07955	2̄.90065	12.57
7	.1443	.02082	.01635	.06309	.79994	15.85
8	.1285	.01651	.01297	.05003	.69924	19.99
9	.1144	.01309	.01028	.03968	.59853	25.20
10	.1019	.01038	.00815	.03146	.49782	31.78
11	0.09074	0.008234	0.006467	0.02495	2̄.39711	40.08
12	.08081	.006530	.005129	.01979	.29641	50.54
13	.07196	.005178	.004067	.01569	.19570	63.72
14	.06408	.004107	.003225	.01244	.09499	80.35
15	.05707	.003257	.002558	.00987	3̄.99429	101.32
16	0.05082	0.002583	0.002028	0.007827	3̄.89358	127.8
17	.04526	.002048	.001609	.006207	.79287	161.1
18	.04030	.001624	.001276	.004922	.69217	203.2
19	.03589	.001288	.001012	.003904	.59146	256.2
20	.03196	.001021	.000802	.003096	.49075	323.1
21	0.02846	0.0008101	0.0006363	0.002455	3̄.39004	408.2
22	.02535	.0006424	.0005046	.001947	.28934	513.6
23	.02257	.0005095	.0004001	.001544	.18863	647.7
24	.02010	.0004040	.0003173	.001224	.08792	816.7
25	.01790	.0003204	.0002517	.000971	4̄.98722	1029.9
26	0.01594	0.0002541	0.0001996	0.0007700	4̄.88651	1298.
27	.01419	.0002015	.0001583	.0006107	.78580	1638.
28	.01264	.0001598	.0001255	.0004843	.68510	2065.
29	.01126	.0001267	.0000995	.0003841	.58439	2604.
30	.01003	.0001005	.0000789	.0003046	.48368	3283.
31	0.008928	0.00007970	0.00006260	0.0002415	4̄.38297	4140.
32	.007950	.00006321	.00004964	.0001915	.28227	5221.
33	.007080	.00005013	.00003937	.0001519	.18156	6583.
34	.006304	.00003975	.00003122	.0001205	.08085	8301.
35	.005614	.00003152	.00002476	.0000955	5̄.98015	10468.
36	0.005000	0.00002500	0.00001963	0.00007576	5̄.87944	13200.
37	.004453	.00001983	.00001557	.00006008	.77873	16644.
38	.003965	.00001372	.00001235	.00004765	.67802	20988.
39	.003531	.00001247	.00000979	.00003778	.57732	26465.
40	.003145	.00000989	.00000777	.00002996	.47661	33372.

CONSTANTS OF COPPER WIRE.

according to the American Brown and Sharp Gauge. British Measure. Temperature 0° C. Density 8.90.

Electrical Constants.

Resistance and Conductivity.					Gauge Number.
Ohms per Foot.	Log.	Feet per Ohm.	Ohms per Pound.	Pounds per Ohm.	
0.00004629	$\bar{5}$.66551	21601.	0.00007219	13852.	0000
.00005837	.76622	17131.	.00011479	8712.	000
.00007361	.86693	13586.	.00018253	5479.	00
.00009282	.96764	10774.	.00029023	3445.	0
0.0001170	$\bar{4}$.06834	8544.	0.0004615	2166.8	1
.0001476	.16905	6775.	.0007338	1362.8	2
.0001861	.26976	5373.	.0011668	857.0	3
.0002347	.37046	4261.	.0018552	539.0	4
.0002959	.47117	3379.	.0029499	339.0	5
0.0003731	$\bar{4}$.57188	2680.	0.004690	213.22	6
.0004705	.67259	2125.	.007458	134.08	7
.0005933	.77329	1685.	.011859	84.32	8
.0007482	.87400	1337.	.018857	53.03	9
.0009434	.97471	1060.	.029984	33.35	10
0.001190	$\bar{3}$.07541	840.6	0.04768	20.973	11
.001500	.17612	666.6	.07581	13.191	12
.001892	.27683	528.7	.12054	8.296	13
.002385	.37753	419.2	.19166	5.218	14
.003008	.47824	332.5	.30476	3.281	15
0.003793	$\bar{3}$.57895	263.7	0.4846	2.0636	16
.004783	.67966	209.1	.7705	1.2979	17
.006031	.78036	165.8	1.2252	0.8162	18
.007604	.88107	131.5	1.9481	.5133	19
.009589	.98178	104.3	3.0976	.3228	20
0.01209	$\bar{2}$.08248	82.70	4.925	0.20305	21
.01525	.18319	65.59	7.832	.12768	22
.01923	.28390	52.01	12.453	.08030	23
.02424	.38461	41.25	19.801	.05051	24
.03057	.48531	32.71	31.484	.03176	25
0.03855	$\bar{2}$.58602	25.94	50.06	0.019976	26
.04861	.68673	20.57	79.60	.012563	27
.06130	.78743	16.31	126.57	.007901	28
.07729	.88814	12.94	201.26	.004969	29
.09746	.98885	10.26	320.01	.003125	30
0.1229	$\bar{1}$.08955	8.137	508.8	0.0019654	31
.1550	.19026	6.452	809.1	.0012359	32
.1954	.29097	5.117	1286.5	.0007773	33
.2464	.39168	4.058	2045.6	.0004889	34
.3107	.49238	3.218	3252.6	.0003074	35
0.3918	$\bar{1}$.59309	2.552	5172.	0.0001934	36
.4941	.69380	2.024	8224.	.0001216	37
.6230	.79450	1.605	13076.	.0000765	38
.7856	.89521	1.273	20792.	.0000481	39
.9906	.99592	1.009	33060.	.0000303	40

SIZE, WEIGHT, AND ELECTRICAL

Size, Weight, and Electrical Constants of pure hard drawn Copper Wire of different numbers

Size and Weight.

Gauge Number.	Diameter in Centimetres.	Square of Diameter (Circular Cms.).	Section in Sq. Cms.	Grammes per Metre.	Log.	Metres per Gramme.
0000	1.1684	1.3652	1.0722	954.3	2.97966	0.001048
000	.0405	.0826	0.8503	756.8	.87896	.001322
00	0.9266	0.8586	.6743	600.1	.77825	.001666
0	.8251	.6809	.5348	475.9	.67754	.002101
1	0.7348	0.5400	0.4241	377.4	2.57684	0.002649
2	.6544	.4282	.3363	299.3	.47613	.003341
3	.5827	.3396	.2667	237.4	.37542	.004213
4	.5189	.2693	.2115	188.2	.27472	.005312
5	.4621	.2136	.1677	149.3	.17401	.006699
6	0.4115	0.16936	0.13302	118.39	2.07330	0.00845
7	.3665	.13431	.10549	93.88	1.97259	.01065
8	.3264	.10651	.08366	74.45	.87189	.01343
9	.2906	.08447	.06634	59.04	.77118	.01694
10	.2588	.06699	.05261	46.82	.67047	.02136
11	0.2305	0.05312	0.04172	37.13	1.56977	0.02693
12	.2053	.04213	.03309	29.45	.46906	.03396
13	.1828	.03341	.02624	23.35	.36835	.04282
14	.1628	.02649	.02081	18.52	.26764	.05400
15	.1450	.02101	.01650	14.69	.16694	.06809
16	0.12908	0.016663	0.013087	11.648	1.06623	0.0859
17	.11495	.013214	.010378	9.237	0.96552	.1083
18	.10237	.010479	.008231	7.325	.86482	.1365
19	.09116	.008330	.006527	5.809	.76411	.1721
20	.08118	.006591	.005176	4.607	.66340	.2171
21	0.07229	0.005227	0.004105	3.653	0.56270	0.2737
22	.06438	.004145	.003255	2.898	.46199	.3450
23	.05733	.003287	.002582	2.298	.36128	.4352
24	.05106	.002607	.002047	1.822	.26057	.5488
25	.04545	.002067	.001624	1.445	.15987	.6920
26	0.04049	0.0016394	0.0012876	1.1459	0.05916	0.873
27	.03606	.0013001	.0010211	.9088	$\bar{1}$.95845	1.100
28	.03211	.0010310	.0008098	.7207	.85775	1.388
29	.02859	.0008176	.0006422	.5715	.75704	1.750
30	.02546	.0006484	.0005093	.4532	.65633	2.206
31	0.02268	0.0005142	0.0004039	0.3594	$\bar{1}$.55562	2.782
32	.02019	.0004078	.0003203	.2850	.45492	3.508
33	.01798	.0003234	.0002540	.2261	.35421	4.424
34	.01601	.0002565	.0002014	.1793	.25350	5.578
35	.01426	.0002034	.0001597	.1422	.15280	7.034
36	0.01270	0.0001613	0.0001267	0.1127	$\bar{1}$.05209	8.87
37	.01131	.0001279	.0001005	.0894	$\bar{2}$.95138	11.18
38	.01007	.0001014	.0000797	.0709	.85068	14.10
39	.00897	.0000804	.0000632	.0562	.74997	17.78
40	.00799	.0000638	.0000501	.0446	.64926	22.43

CONSTANTS OF COPPER WIRE.

According to the American Brown and Sharp Gauge. Metric Measure. Temperature 0° C. Density 8.90.

Electrical Constants.

Resistance and Conductivity.					
Ohms per Metre.	Log.	Metres per Ohm.	Ohms per Gramme.	Grammes per Ohm.	Gauge Number.
0.0001519	$\bar{4}$.18150	6584.	0.0000001592	6283000.	0000
.0001915	.28221	5221.	.0000002531	3951000.	000
.0002415	.38191	4141.	.0000004024	2485000.	00
.0003045	.48362	3284.	.0000006398	1563000.	0
0.0003840	$\bar{4}$.58433	2604.	0.000001017	982900.	1
.0004842	.68503	2065.	.000001618	618200.	2
.0006106	.78574	1638.	.000002572	388800.	3
.0007699	.88645	1299.	.000004090	244500.	4
.0009709	.98715	1030.	.000006504	153800.	5
0.001224	$\bar{3}$.08786	816.9	0.00001034	96700.	6
.001544	.18857	647.8	.00001644	60820.	7
.001947	.28928	513.7	.00002615	38250.	8
.002455	.38998	407.4	.00004157	24050.	9
.003095	.49069	323.1	.00006610	15130.	10
0.003903	$\bar{3}$.59140	256.2	0.00010511	9514.	11
.004922	.69210	203.2	.00016712	5984.	12
.006206	.79281	161.1	.00026574	3763.	13
.007826	.89352	127.8	.00042254	2367.	14
.009868	.99423	101.3	.00067187	1488.	13
0.01244	$\bar{2}$.09493	80.37	0.0010683	936.1	16
.01569	.19564	63.73	.0016987	588.7	17
.01979	.29635	50.54	.0027010	370.2	18
.02495	.39705	40.08	.0042948	232.8	19
.03146	.49776	31.79	.0068290	146.4	20
0.03967	$\bar{2}$.59847	25.21	0.010859	92.09	21
.05002	.69917	19.99	.017266	57.92	22
.06308	.79988	15.85	.027454	36.42	23
.07954	.90059	12.57	.043653	22.91	24
.10030	$\bar{1}$.00130	9.97	.069411	11.88	25
0.12647	$\bar{1}$.10200	7.907	0.11037	9.060	26
.15948	.20271	6.270	.17549	5.698	27
.20110	.30342	4.973	.27904	3.584	28
.25358	.40412	3.943	.44369	2.254	29
.31976	.50483	3.127	.70550	1.417	30
0.4032	$\bar{1}$.60554	2.480	1.1218	0.8914	31
.5084	.70624	1.967	1.7837	.5606	32
.6411	.80695	1.560	2.8362	.3526	33
.8085	.90766	1.237	4.5097	.2217	34
1.0194	0.00837	0.981	7.1708	.1394	35
1.2855	0.10907	0.7779	11.376	0.08790	36
1.6210	.20978	.6169	18.130	.05516	37
2.0440	.31049	.4892	28.828	.03469	38
2.5775	.41119	.3880	45.838	.02182	39
3.2501	.51190	.3076	72.885	.01372	40

Size, Weight, and Electrical Constants of pure hard drawn Copper Wire of different numbers.

Size and Weight.

Gauge Number.	Diameter in Inches.	Square of Diameter (Circular Inches).	Section in Sq. Inches.	Pounds per Foot.	Log.	Feet per Pound.
7–0	0.500	0.2500	0.1963	0.75760	$\bar{1}.87944$	1.320
6–0	.464	.2153	.1691	.65243	.81453	1.583
5–0	0.432	0.1866	0.1466	0.56554	$\bar{1}.75247$	1.768
4–0	.400	.1600	.1257	.48486	.68562	2.062
3–0	.372	.1384	.1087	.41936	.62258	2.385
2–0	.348	.1211	.0951	.36699	.56466	2.725
0	.324	.1050	.0825	.31812	.50259	3.143
1	0.300	0.09000	0.07069	0.27274	$\bar{1}.43574$	3.667
2	.276	.07618	.05983	.23084	.36332	4.332
3	.252	.06350	.04988	.19244	.28430	5.196
4	.232	.05382	.04227	.16310	.21246	6.131
5	.212	.04494	.03530	.13620	.13417	7.342
6	0.192	0.03686	0.02895	0.11171	$\bar{1}.04810$	8.95
7	.176	.03098	.02433	.09387	$\bar{2}.97252$	10.65
8	.160	.02560	.02010	.07758	.88974	12.89
9	.144	.02074	.01629	.06284	.79822	15.91
10	.128	.01638	.01287	.04965	.69592	20.14
11	0.116	0.013456	0.010568	0.04078	$\bar{2}.61041$	24.52
12	.104	.010816	.008495	.03278	.51557	30.51
13	.092	.008464	.006648	.02565	.40907	38.99
14	.080	.006400	.005027	.01939	.28768	51.56
15	.072	.005184	.004071	.01571	.19616	63.66
16	0.064	0.004096	0.003217	0.012412	$\bar{2}.09386$	80.6
17	.056	.003136	.002463	.009503	$\bar{3}.97787$	105.2
18	.048	.002304	.001810	.006982	.84398	143.2
19	.040	.001600	.001257	.004849	.68502	206.2
20	.036	.001296	.001018	.003927	.59410	254.6
21	0.032	0.0010240	0.0008042	0.003103	$\bar{3}.49180$	322.3
22	.028	.0007840	.0006157	.002376	.37581	420.9
23	.024	.0005760	.0004524	.001746	.24192	572.9
24	.022	.0004840	.0003801	.001467	.16634	681.8
25	.020	.0004000	.0003141	.001212	.08356	824.9
26	0.0180	0.0003240	0.0002545	0.0009818	$\bar{4}.99209$	1018.
27	.0164	.0002690	.0002112	.0008151	.91119	1227.
28	.0148	.0002190	.0001728	.0006638	.82202	1506.
29	.0136	.0001850	.0001453	.0005605	.74858	1784.
30	.0124	.0001538	.0001208	.0004660	.66834	2146.
31	0.0116	0.00013456	0.00010568	0.0004078	$\bar{4}.61041$	2452.
32	.0108	.00011664	.00009161	.0003535	.54835	2829.
33	.0100	.00010000	.00007854	.0003030	.48150	3300.
34	.0092	.00008464	.00006648	.0002565	.40907	3899.
35	.0084	.00007056	.00005542	.0002138	.33006	4677.
36	0.0076	0.00005776	0.00004536	0.0001750	$\bar{4}.24313$	5713.
37	.0068	.00004624	.00003632	.0001404	.14752	7120.
38	.0060	.00003600	.00002827	.0001091	.03780	9167.
39	.0052	.00002704	.00002124	.0000819	$\bar{5}.91351$	12200.
40	.0048	.00002304	.00001810	.0000682	.84398	14660.
41	0.0044	0.00001936	0.00001521	0.00005867	$\bar{5}.76840$	17050.
42	.0040	.00001600	.00001257	.00004849	.68562	20620.
43	.0036	.00001296	.00001018	.00003927	.59410	25460.
44	.0032	.00001024	.00000804	.00003103	.49180	32230.
45	.0028	.00000784	.00000616	.00002381	.37681	41990.
46	0.0024	0.00000576	0.00000452	0.00001746	$\bar{5}.24192$	57290.
47	.0020	.00000400	.00000314	.00001212	.08356	82490.
48	.0016	.00000256	.00000201	.00000776	$\bar{6}.88974$	128900.
49	.0012	.00000144	.00000113	.00000436	.63986	229200.
50	.0010	.00000100	.00000079	.00000303	.48150	330000.

CONSTANTS OF COPPER WIRE.

according to the British Standard Wire Gauge. British Measure. Temperature 0° C. Density 8.90.

Electrical Constants.

Resistance and Conductivity.					Gauge Number.
Ohms per Foot.	Log.	Feet per Ohm.	Ohms per Pound.	Pounds per Ohm.	
0.00003918	$\bar{5}$.59310	25520.	0.000051719	19335.	7-0
.00004550	.65799	21980.	.000069736	14339.	6-0
0.00005249	$\bar{5}$.72006	19050.	0.00009281	10775.	5-0
.00006122	.78691	16330.	.00012627	7920.	4-0
.00007078	.84994	14130.	.00016880	5924.	3-0
.00008089	.90787	12360.	.00022040	4537.	2-0
.00009331	.96994	10720.	.00029333	3409.	0
0.0001088	$\bar{4}$.03679	9188.	0.0003991	2505.8	1
.0001286	.10921	7777.	.0005570	1795.2	2
.0001543	.18823	6483.	.0008015	1247.7	3
.0001820	.26005	5495.	.0011158	896.2	4
.0002180	.33836	4588.	.0016002	624.2	5
0.0002657	$\bar{4}$.42443	3763.	0.0023786	420.4	6
.0003162	.50000	3162.	.0033688	296.9	7
.0003826	.58279	2613.	.0049323	202.7	8
.0004724	.67430	2117.	.0075176	133.0	9
.0005979	.77661	1673.	.0084978	117.7	10
0.0007280	$\bar{4}$.86211	1373.6	0.017853	56.013	11
.0009056	.95696	1104.2	.027631	36.191	12
.0011573	$\bar{3}$.06345	864.1	.045121	22.163	13
.0015305	.18485	653.4	.078927	12.669	14
.0018896	.27636	529.2	.120282	8.314	15
0.002391	$\bar{3}$.37867	418.1	0.19267	5.1902	16
.003124	.49465	320.2	.32868	3.0423	17
.004252	.62855	235.2	.60893	1.6423	18
.006122	.78691	163.3	1.26268	0.7919	19
.007558	.87842	132.3	1.92451	.5196	20
0.00957	$\bar{3}$.98073	104.54	3.0827	0.32439	21
.01249	$\bar{2}$.09671	80.04	5.2599	.19011	22
.01701	.23061	58.80	9.7429	.10264	23
.02024	.30618	49.41	13.7988	.07246	24
.02506	.38897	39.91	20.2028	.04951	25
0.03023	$\bar{2}$.48048	33.08	30.792	0.032478	26
.03642	.56134	27.46	56.254	.017778	27
.04472	.65051	22.36	67.373	.014843	28
.05296	.72395	18.88	94.488	.010583	29
.06371	.80419	15.70	136.724	.007314	30
0.07449	$\bar{2}$.87211	13.42	182.68	0.005474	31
.08398	.92418	11.91	237.59	.004209	32
.09796	.99103	10.21	323.25	.003094	33
.11573	$\bar{1}$.06345	8.64	451.21	.002216	34
.13883	.14247	7.20	649.25	.001540	35
0.16959	$\bar{1}$.22940	5.897	968.9	0.0010321	36
.21184	.32601	4.720	1508.3	.0006630	37
.27210	.43473	3.675	2494.2	.0004009	38
.36226	.55902	2.760	4421.0	.0002262	39
.42515	.62855	2.352	6089.3	.0001642	40
0.5060	$\bar{1}$.70412	1.976	8624.	0.00011596	41
.6122	.78691	.633	12627.	.00007919	42
.7558	.87842	.323	19245.	.00005196	43
.9566	.98073	.045	30827.	.00003244	44
1.2494	0.09671	0.800	52468.	.00001906	45
1.7006	0.23061	0.5880	97429.	0.000010264	46
2.5059	.38897	.3991	202028.	.000004950	47
3.8264	.58279	.2613	493232.	.000002027	48
6.8025	.83267	.1470	1558851.	.000000642	49
9.7956	.99103	.1021	3232451.	.000000196	50

SIZE, WEIGHT, AND ELECTRICAL

Size, Weight, and Electrical Constants of pure hard drawn Copper Wire of different numbers

Size and Weight.

Gauge Number.	Diameter in Centimetres.	Square of Diameter (Circular Cms.).	Section in Sq. Cms.	Grammes per Metre.	Log.	Metres per Gramme.
7–0	1.2700	1.6129	1.267	1127.4	3.05209	0.000887
6–0	.1786	.3890	.091	970.9	2.98719	.001032
5–0	1.0973	1.2040	0.9456	841.6	2.92512	0.001188
4–0	.0160	.0323	.8107	721.6	.85827	.001386
3–0	0.9449	0.8928	.7012	624.1	.79524	.001602
2–0	.8839	.7815	.6136	546.3	.73741	.001831
0	.8230	.6773	.5319	484.4	.68524	.002064
1	0.7620	0.58065	0.4560	405.9	2.60839	0.002464
2	.7010	.49157	.3858	343.6	.53607	.002910
3	.6401	.40970	.3218	286.4	.45695	.003492
4	.5893	.34725	.2727	242.7	.38512	.004120
5	.5385	.28996	.2277	202.7	.30682	.004934
6	0.4877	0.23783	0.18679	166.25	2.22075	0.006015
7	.4470	.19984	.15696	139.69	.14517	.007159
8	.4064	.16516	.12973	115.45	.06239	.008662
9	.3658	.13378	.10507	93.51	1.97087	.010694
10	.3251	.10570	.08302	73.89	.86857	.013533
11	0.2946	0.08681	0.06818	60.68	1.78307	0.01648
12	.2642	.06978	.05480	48.78	.68822	.02051
13	.2337	.05461	.04289	38.17	.58172	.02620
14	.2032	.04129	.03243	28.86	.46033	.03465
15	.1829	.03344	.02627	23.38	.36881	.04278
16	0.16256	0.026426	0.020755	18.514	1.26751	0.05401
17	.14224	.020233	.015890	14.142	.15053	.07071
18	.12192	.014865	.011675	10.390	.01663	.09625
19	.10160	.010323	.008107	7.216	0.85827	.13858
20	.09144	.008361	.006567	5.845	.76675	.17109
21	0.08128	0.006606	0.005188	4.618	0.66445	0.2165
22	.07112	.005058	.003972	3.536	.54847	.2828
23	.06096	.003716	.002922	2.598	.41457	.3850
24	.05588	.003123	.002452	2.183	.33899	.4581
25	.05080	.002581	.002027	1.804	.25621	.5544
26	0.04572	0.0020903	0.0016417	1.4625	0.16509	0.6838
27	.04166	.0017352	.0013628	.2129	.08384	.8245
28	.03759	.0014132	.0011099	0.9878	$\bar{1}$.99467	1.0123
29	.03454	.0011922	.0009363	.8333	.92083	.2000
30	.03150	.0009920	.0007791	.6934	.84099	.4422
31	0.02946	0.0008681	0.0006818	0.6068	$\bar{1}$.78307	1.648
32	.02743	.0007525	.0005910	.5260	.72100	1.901
33	.02540	.0006452	.0005067	.4510	.65415	2.217
34	.02337	.0005461	.0004289	.3817	.58172	2.620
35	.02134	.0004552	.0003575	.3182	.50271	3.143
36	0.01930	0.0003726	0.0002927	0.2605	$\bar{1}$.41578	3.839
37	.01727	.0002983	.0002343	.2090	.31917	4.784
38	.01524	.0002323	.0001824	.1623	.21045	6.160
39	.01321	.0001746	.0001370	.1219	.08616	8.201
40	.01219	.0001486	.0001167	.1039	.01663	9.625
41	0.01118	0.0001249	0.0000982	0.0873	$\bar{2}$.94105	11.45
42	.01016	.0001032	.0000813	.0722	.85827	13.86
43	.00914	.0000836	.0000656	.0584	.76675	17.11
44	.00813	.0000661	.0000519	.0462	.66445	21.65
45	.00711	.0000506	.0000397	.0354	.54847	28.28
46	0.00610	0.00003716	0.0000292	0.0260	$\bar{2}$.41457	38.5
47	.00508	.00002581	.0000203	.0180	.25621	55.4
48	.00406	.00001652	.0000129	.0115	.06239	86.6
49	.00305	.00000929	.0000073	.0065	$\bar{3}$.81251	154.0
50	.00254	.00000645	.0000051	.0045	.65415	221.8

CONSTANTS OF COPPER WIRE.

according to the British Standard Wire Gauge. Metric Measure. Temperature 0° C. Density 8.90.

Electrical Constants.

Resistance and Conductivity.					Gauge Number.
Ohms per Metre.	Log.	Metres per Ohm.	Ohms per Gramme.	Grammes per Ohm.	
0.0001286	$\bar{4}$.10907	7779.	0.0000001140	8770000.	7–0
.0001493	.17398	6699.	.0000001537	6504000.	6–0
0.0001722	$\bar{4}$.23605	5814.	0.0000002046	4887000.	5–0
.0002009	.30289	4979.	.0000002784	3592000.	4–0
.0002322	.36593	4306.	.0000003721	2687000.	3–0
.0002653	.42376	3769.	.0000004857	2059000.	2–0
.0003061	.48592	3266.	.0000006319	1583000.	0
0.0003571	$\bar{4}$.55277	2801.	0.0000008798	1137000.	**1**
.0004218	.62510	2371.	.0000012275	814700.	2
.0005061	.70421	1976.	.0000017671	565900.	3
.0005971	.77604	1675.	.0000024600	406500.	4
.0007151	.85434	1398.	.0000035279	283500.	5
0.0008718	$\bar{4}$.94041	1147.1	0.000005244	190700.	**6**
.0010375	$\bar{3}$.01599	963.9	.000009350	107000.	7
.0012554	.09877	796.6	.000010874	91960.	8
.0015499	.19029	645.2	.000016573	60340.	9
.0019615	.29259	509.8	.000026547	37670.	10
0.002388	$\bar{3}$.37810	418.7	0.00003936	25410.	**11**
.002978	.47295	335.8	.00006092	16420.	12
.003796	.57934	263.4	.00009945	10060.	13
.005022	.70083	199.1	.00017398	5748.	14
.006199	.79235	161.3	.00026518	3771.	15
0.007846	$\bar{3}$.89465	127.45	0.0004238	2359.6	**16**
.010248	$\bar{2}$.01064	97.58	.0007246	1380.1	17
.013949	.14453	71.69	.0013425	744.9	18
.020086	.30289	49.79	.0027837	359.2	19
.024798	.39441	40.32	.0042428	235.7	20
0.03138	$\bar{2}$.49671	31.86	0.005398	185.25	**21**
.04099	.61270	24.39	.011594	86.25	22
.05579	.74659	17.92	.021479	46.56	23
.06640	.82217	15.06	.030421	32.87	24
.08034	.90495.	12.45	.044539	22.45	25
0.09919	$\bar{2}$.99647	10.082	0.06782	14.745	**26**
.11949	$\bar{1}$.07733	8.369	.09851	10.151	27
.14672	.16649	6.816	.14853	6.732	28
.17391	.24034	5.750	.20869	4.792	29
.20901	.32017	4.784	.30142	3.318	30
0.2388	$\bar{1}$.37810	4.187	0.3936	2.5407	**31**
.2755	.44017	3.629	.5238	1.9091	32
.3214	.50701	3.112	.7126	1.4033	33
.3797	.57944	2.634	.9947	1.0053	34
.4555	.65846	2.196	1.4313	0.6987	35
0.5564	$\bar{1}$.74539	1.7973	2.136	0.46816	**36**
.6950	.84200	.4388	3.333	.30003	37
.8927	.95070	.1202	7.019	.14247	38
1.1885	0.07501	0.8414	9.747	.10260	39
.3949	.14453	.7169	13.424	.07449	40
1.660	0.22011	0.6024	19.01	0.05260	**41**
2.009	.30289	.4979	27.84	.03592	42
2.480	.39441	.4033	42.43	.02357	43
3.138	.49671	.3186	67.96	.01471	44
4.099	.61270	.2440	115.94	.00863	45
5.579	0.74659	0.1792	210.4	0.004753	**46**
8.034	.90495	.1245	445.4	.002245	47
12.554	1.09877	.0797	1087.4	.000920	48
22.318	.34865	.0448	3436.7	.000291	49
32.138	.50701	.0311	7126.3	.000140	50

TABLE 69.

SIZE, WEIGHT, AND ELECTRICAL

Size, Weight, and Electrical Constants of pure hard drawn Copper Wire of different numbers

Size and Weight.

Gauge Number.	Diameter in Inches.	Square of Diameter (Circular Inches).	Sections in Sq. Inches.	Pounds per Foot.	Log.	Feet per Pound.
0000	0.454	0.2061	0.16188	0.6246	$\bar{1}.79561$	1.601
000	.425	.1806	.14186	.5474	.73828	1.827
00	.380	.1440	.11341	.4376	.64107	2.285
0	.340	.1156	.09079	.3503	.54446	2.855
1	0.300	0.09000	0.07069	0.2727	$\bar{1}.43574$	3.666
2	.284	.08065	.06335	.2444	.38814	4.091
3	.259	.06708	.05269	.2033	.30810	4.919
4	.238	.05664	.04449	.1717	.23465	5.826
5	.220	.04840	.03801	.1467	.16634	6.818
6	0.203	0.04121	0.03237	0.12488	$\bar{1}.09649$	8.008
7	.180	.03240	.02545	.09818	$\bar{2}.99204$	10.185
8	.165	.02723	.02138	.08250	.91647	12.121
9	.148	.02190	.01720	.06638	.82202	15.065
10	.134	.01796	.01410	.05441	.73571	18.379
11	0.120	0.014400	0.011310	0.04364	$\bar{2}.63986$	22.91
12	.109	.011881	.009331	.03600	.55635	27.77
13	.095	.009025	.007088	.02735	.43695	36.56
14	.083	.006889	.005411	.02088	.31965	47.90
15	.072	.005184	.004072	.01571	.19616	63.65
16	0.065	0.004225	0.0033183	0.012803	$\bar{2}.10733$	78.10
17	.058	.003364	.0026421	.010194	.00835	98.10
18	.049	.002401	.0018857	.007276	$\bar{3}.86189$	137.44
19	.042	.001764	.0013854	.005346	.72800	187.06
20	.035	.001225	.0009621	.003712	.56963	269.40
21	0.032	0.001024	0.0008042	0.003103	$\bar{3}.49180$	322.3
22	.028	.000784	.0006158	.002376	.37581	420.9
23	.025	.000625	.0004909	.001894	.27738	528.0
24	.022	.000484	.0003801	.001467	.16634	681.8
25	.020	.000400	.0003142	.001212	.08356	824.9
26	0.018	0.000324	0.0002545	0.0009818	$\bar{4}.99204$	1018.
27	.016	.000256	.0002011	.0007758	.88974	1289.
28	.014	.000196	.0001539	.0005940	.77375	1684.
29	.013	.000169	.0001327	.0005121	.70939	1953.
30	.012	.000144	.0001131	.0004364	.63986	2292.
31	0.010	0.000100	0.00007854	0.00030304	$\bar{4}.48150$	3300.
32	.009	.000081	.00006362	.00024546	.38998	4074.
33	.008	.000064	.00005027	.00019395	.28768	5156.
34	.007	.000049	.00003848	.00014849	.17169	6734.
35	.005	.000025	.00001963	.00007576	$\bar{5}.87944$	13200.
36	0.004	0.000016	0.00001257	0.00004849	$\bar{5}.68562$	20620.

CONSTANTS OF COPPER WIRE.

according to the Birmingham Wire Gauge. British Measure. Temperature 0° C. Density 8.90.

Electrical Constants.

Resistance and Conductivity.					Gauge Number.
Ohms per Foot.	Log.	Feet per Ohm.	Ohms per Pound.	Pounds per Ohm.	
0.00004752	$\bar{5}$.67692	21040.	0.0000761	13140.	0000
.00005423	.73425	18440.	.0000991	10090.	000
.00006784	.83146	14740.	.0001550	6451.	00
.00008474	.92807	11800.	.0002419	4134.	0
0.0001088	$\bar{4}$.03679	9188.	0.0003991	2505.8	1
.0001214	.08439	8234.	.0004969	2012.5	2
.0001460	.16443	6848.	.0007183	1392.2	3
.0001729	.23788	5783.	.0010074	992.6	4
.0002024	.30618	4941.	.0013799	724.7	5
0.0002377	$\bar{4}$.37604	4207.	0.001903	525.26	6
.0003023	.48048	3308.	.003079	324.76	7
.0003598	.55606	2779.	.004361	229.30	8
.0004472	.65051	2236.	.006737	148.43	9
.0005455	.73682	1833.	.010025	99.75	10
0.0006802	$\bar{4}$.83267	1470.2	0.01559	64.148	11
.0008245	.91618	1212.9	.02290	43.670	12
.0010854	$\bar{3}$.03558	921.3	.03969	25.195	13
.0014219	.15287	703.3	.06811	14.682	14
.0018896	.27636	529.2	.12028	8.314	15
0.002318	$\bar{3}$.36520	431.3	0.1811	5.5225	16
.002980	.47417	335.6	.2923	3.4211	17
.004080	.61064	245.1	.5607	1.7835	18
.005553	.74453	180.1	1.0388	0.9627	19
.007996	.90289	125.1	2.1541	.4643	20
0.009566	$\bar{3}$.98073	104.54	3.083	0.32439	21
.012494	$\bar{2}$.09671	80.04	5.259	.19015	22
.015709	.19515	63.66	8.275	.12085	23
.020239	.30618	49.41	13.799	.07246	24
.024489	.38897	40.83	20.203	.04950	25
0.02887	$\bar{2}$.46048	34.64	29.41	0.034006	26
.03826	.58279	26.13	49.32	.020275	27
.04998	.69877	20.01	84.14	.011885	28
.05796	.76314	17.25	113.18	.008835	29
.06802	.83266	14.70	155.88	.006415	30
0.09796	$\bar{2}$.99103	10.209	323.2	0.0030936	31
.12095	$\bar{1}$.08254	8.269	492.7	.0020290	32
.15306	.18485	6.533	789.2	.0012671	33
.19991	.30083	5.002	1346.3	.0007420	34
.39182	.59309	2.552	5171.9	.0001933	35
0.61222	$\bar{1}$.78691	1.663	12627.	0.00007920	36

SIZE, WEIGHT, AND ELECTRICAL

Size, Weight, and Electrical Constants of pure hard drawn Copper Wire of different numbers.

Size and Weight.

Gauge Number.	Diameter in Centimetres.	Square of Diameter (Circular Cms.).	Section in Sq. Cms.	Grammes per Metre.	Log.	Metres per Gramme.
0000	1.1532	1.3298	1.0444	929.5	2.96826	0.001076
000	.0795	.1653	.9152	814.6	.91093	.001228
00	0.9652	0.9316	.7317	651.2	.81372	.001536
0	.8636	.7458	.5858	521.3	.71711	.001918
1	0.7620	0.5806	0.4560	405.9	2.60839	0.002464
2	.7214	.5216	.4087	363.7	.56079	.002749
3	.6579	.4328	.3399	302.5	.48075	.003306
4	.6045	.3655	.2870	255.4	.40730	.003915
5	.5588	.3123	.2452	218.3	.33899	.004581
6	0.5156	0.2659	0.20881	185.84	2.26914	0.005381
7	.4572	.2090	.16417	146.11	.16469	.006844
8	.4191	.1756	.13795	122.78	.08912	.008145
9	.3759	.1413	.11099	98.78	1.99467	.010124
10	.3404	.1158	.09098	80.98	.90836	.012349
11	0.3048	0.09290	0.07297	64.94	1.81251	0.01540
12	.2769	.07665	.06160	54.83	.73900	.01824
13	.2413	.05823	.04573	40.70	.60960	.02457
14	.2108	.04445	.03491	31.07	.49231	.03219
15	.1829	.03345	.02627	23.43	.36981	.04268
16	0.16510	0.027258	0.021409	19.054	1.27998	0.05248
17	.14732	.021703	.017046	15.171	.18101	.06592
18	.12446	.015490	.012166	10.828	.03454	.09235
19	.10668	.011381	.008938	7.955	0.90065	.12571
20	.08890	.007903	.006207	5.524	.74229	.18103
21	0.08128	0.006606	0.005189	4.618	0.66445	0.2165
22	.07112	.005058	.003973	3.536	.54847	.2828
23	.06350	.004032	.003167	2.820	.45003	.3547
24	.05588	.003123	.002452	2.183	.33899	.4581
25	.05080	.002581	.002027	1.804	.25621	.5544
26	0.04572	0.0020903	0.0016418	1.4611	0.16469	0.6844
27	.04064	.0016516	.0012972	.1545	.06239	.8662
28	.03556	.0012645	.0009932	0.8839	$\bar{1}.94641$	1.1313
29	.03302	.0010903	.0008563	.7621	.88204	.3122
30	.03048	.0009290	.0007297	.6494	.81251	.5399
31	0.02540	0.0006452	0.0005067	0.4510	$\bar{1}.65415$	2.217
32	.02286	.0005226	.0004104	.3653	.56263	2.738
33	.02032	.0004129	.0003243	.2886	.46033	3.465
34	.01778	.0003161	.0002483	.2210	.34435	4.525
35	.01270	.0001613	.0001267	.1127	.05209	8.870
36	0.01016	0.0001032	0.0000811	0.0722	$\bar{2}.85827$	13.861

CONSTANTS OF COPPER WIRE.

according to the Birmingham Wire Gauge. Metric Measure. Temperature 0° C. Density 8.90.

Electrical Constants.

Resistance and Conductivity.					Gauge Number.
Ohms per Metre.	Log.	Metres per Ohm.	Ohms per Gramme.	Grammes per Ohm.	
0.0001559	$\bar{4}$.19290	6414.	0.0000001677	5962000.	0000
.0001779	.25024	5620.	.0000002184	4578000.	000
.0002226	.34745	4493.	.0000003418	2926000.	00
.0002780	.44406	3597.	.0000005333	1875000.	0
0.0003571	$\bar{4}$.55277	2800.	0.0000008798	1137000.	1
.0003985	.60038	2510.	.0000010955	912800.	2
.0004791	.68041	2087.	.0000015837	631400.	3
.0005674	.75386	1763.	.0000022210	450200.	4
.0006640	.82217	1506.	.0000030420	328700.	5
0.0007799	$\bar{4}$.89202	1282.2	0.000004196	238300.	6
.0009257	.99647	1080.3	.000006789	147300.	7
.0011804	$\bar{3}$.07205	847.2	.000009615	104000.	8
.0014672	.16649	681.6	.000014853	67330.	9
.0017898	.25280	558.7	.000022103	45240.	10
0.002232	$\bar{3}$.34865	448.1	0.00003437	29100.	11
.002643	.42216	378.3	.00004822	20740.	12
.003561	.55157	280.8	.00008749	11430.	13
.004665	.66886	214.4	.00015016	6660.	14
.006185	.79135	161.7	.00026396	3789.	15
0.007607	$\bar{3}$.88119	131.46	0.0003992	2504.9	16
.009553	.98016	104.68	.0006297	1588.0	17
.013385	$\bar{2}$.12662	74.71	.0012362	808.9	18
.018219	.26052	54.89	.0022902	436.6	19
.026235	.41888	38.12	.0047489	210.6	20
0.03138	$\bar{2}$.49671	31.86	0.006796	147.14	21
.04099	.61270	24.39	.011594	86.25	22
.05142	.71113	19.45	.018243	54.82	23
.06640	.82217	15.06	.030421	32.87	24
.08034	.90495	12.45	.044539	22.45	25
0.09919	$\bar{2}$.99647	10.08	0.06789	14.731	26
.12583	$\bar{1}$.09877	7.947	.10874	9.196	27
.16397	.21476	6.099	.18550	5.391	28
.19016	.27913	5.259	.24951	4.008	29
.22138	.34865	4.517	.34367	2.910	30
0.3214	$\bar{1}$.50701	3.112	0.7126	1.4032	31
.3968	.59853	2.520	1.0862	0.9206	32
.5022	.70083	1.991	1.7398	.5748	33
.6559	.81682	1.525	2.9861	.3349	34
1.2855	0.10907	0.778	11.4020	.0877	35
2.0086	0.30289	0.498	27.8370	0.0359	36

(a) METALS.

Name of metal.	Tensile strength in pounds per sq. in.
Aluminium wire	30000–40000
Brass wire, hard drawn	50000–150000
Bronze, phosphor, hard drawn	110000–140000
" silicon " "	95000–115000
Copper wire, hard drawn	60000–70000
Gold † wire	38000–41000
Iron,‡ cast	13000–29000
" wire, hard drawn	80000–120000
" " annealed	50000–60000
Lead, cast or drawn	2600–3300
Palladium †	39000
Platinum † wire	50000
Silver † wire	42000
Steel, mild, hard drawn	100000–200000
" hard " "	150000–33000
Tin, cast or drawn	4000–5000
Zinc, cast	7000–13000
" drawn	22000–30000

(b) STONES AND BRICKS.

Name of substance.	Resistance to crushing in pounds per sq. in.
Basalt	18000–27000
Brick, soft	300–1500
" hard	1500–5000
" vitrified	9000–26000
Granite	17000–26000
Limestone	4000–9000
Marble	9000–22000
Sandstone	4500–8000
Slate	11000–30000

(c) TIMBER.

Name of wood.	Tensile strength in pounds per sq. in.	Resistance to crushing in pounds per sq. in.
Ash	11000–21000	6000–9000
Beech	11000–18000	9000–10000
Birch	12000–18000	5000–7000
Chestnut	10000–13000	4000–6000
Elm	12000–18000	6000–10000
Hackberry	10000–16000	— —
Hickory	15000–25000	7000–12000
Maple	8000–12000	6000–8000
Mulberry	8000–14000	— —
Oak, burr	15000–20000	7000–10000
" red	13000–18000	5000–7000
" water	12000–16000	4000–6000
" white	20000–25000	6000–9000
Poplar	10000–15000	5000–8000
Walnut	8000–14000	4000–8000

* The strength of most materials is so variable that very little is gained by simple tabulation of the results which have been obtained. A few approximate results are given for materials of common occurrence, mainly to indicate the limits between which the strength of fairly good specimens may lie. Some tables are also given indicating the relation of strength to composition in the case of alloys. It has not been thought worth while to state these results in other than the ordinary inch pound units.

† On the authority of Wertheim.

‡ The crushing strength of cast iron is from 5.5 to 6.5 times the tensile strength.

NOTES. — According to Boys, quartz fibres have a tensile strength of between 116000 and 167000 pounds per square inch.

Leather belting of single thickness bears from 400 to 1600 pounds per inch of its breadth.

Percentages of S.	P.	Si.	C.	Mn.	Cu.	Co.	Ni.	Sb.	Strength at yield point ÷ 100.	Ultimate strength† ÷ 100.	Young's Modulus ÷ 10^5.	Resilience to yield point in inch pounds.	Resilience to rupture in inch pounds ÷ 100.	Elongation per cent.
.004	.014	.145	.257	.020	.002	.008	.010		216	379	246	9.5	106	30.9
.009	.084	.163	.009	.020	.023	.021	.016		252	434	260	12.3	129	32.6
.011	.109	.168	.042	.051	.028	.028	.044		276	481	234	17.4	119	27.5
.027	.247	.216	.036	.072	.027	.048	.070		322	529	243	24.7	117	24.9
.014	.029	.037	.161	.121	.001	trace	trace		317	534	277	18.4	151	32.0
trace	.039	.084	.234	.000	.014	.036	.057	.115	260	605	250	15.6	110	20.8
.008	.034	.073	.316	.064	.008	.016	.023		419	649	263	37.9	130	22.3
.056	.113	.007	.139	.165	.364	.076	.107		478	687	261	46.3	110	18.1
.004	.024	.087	.447	.072	.005	.018	.023		461	755	271	46.0	124	18.6
.058	.128	.013	.254	.341	.278	.045	.065		487	785	293	55.0	91	15.5
.066	.099	.016	.326	.525	.306	.054	.078		549	793	255	58.0	38	5.6
.002	.022	.123	.595	.124	.001	.007	.006		480	828	267	42.7	151	21.0
.008	.062	.071	.447	.493	.007	.040	.065		484	859	284	38.2	174	22.7
.041	.125	.028	.355	.404	.253	.049	.102		543	880	254	55.9	49	6.7
.062	.138	.018	.390	.584	.344	.073	.110		565	953	259	73.7	44	5.6
.002	.020	.096	.652	.061	.030	.007	.018		510	955	269	50.2	112	13.7
.002	.026	.164	.935	.099	.004	.018	.016		557	957	278	65.3	123	16.6
.043	.104	.074	.756	.465	.346	.052	.120		652	1010	237	94.6	14	1.7
.028	.065	.028	.690	.459	.022	.000	.000		516	1022	285	55.6	37	4.6
.003	.031	.204	.929	.129	.007	.013	.010		590	1050	284	62.1	148	16.0
.038	.092	.070	.387	.625	.210	.050	.115		631	1112	279	83.2	135	13.7
.001	.015	.150	.971	.074	.003	.003	.015		555	1171	262	65.6	99	9.9
.000	.019	.192	1.105	.226	.001	.002	.004		668	1254	272	82.7	93	9.0
.014	.063	.043	.681	.625	.038	.000	.000		614	1288	260	82.2	108	9.9

STEEL CONTAINING CHROMIUM.

S.	P.	Si.	C.	Mn.	Cu.	Co.	Cr.	Strength at yield point ÷ 100.	Ultimate strength ÷ 100.	Young's Modulus ÷ 10^5.	Resilience to yield point.	Resilience to rupture ÷ 100.	Elongation per cent.
trace	.020	.116	.461	.027	trace	.000	.612 Cr.	370	810	275	28.3	110	15.6
.001	.019	.136	.454	.023	.000	.000	.921 Cr.	495	915	287	44.8	157	19.1
trace	.007	.154	.639	.050	.008	trace	1.044 Cr.	500	967	281	56.1	25	3.5
—	—	—	.600	—	—	—	2.200 Cr.	675	1030	—	—	—	19.9
—	—	—	1.100	—	—	—	4.000 Cr.	1770	1778	—	—	—	7.5

STEEL CONTAINING TUNGSTEN.

S.	P.	Si.	C.	Mn.		Strength at yield point ÷ 100.	Ultimate strength ÷ 100.	Young's Modulus ÷ 10^5.	Resilience to yield point.	Resilience to rupture ÷ 100.	Elongation per cent.
—	—	.09	1.99	.19	7.81 per cent tungsten .	—	1464	—	—	—	0.0
—	—	.05	2.06	2.66	6.73 " " "	—	760	—	—	—	0.0
Same after heating to dull red and quenching in oil					.	—	940	—	—	—	0.0
—	—	.21	1.20	.35	6.45 per cent tungsten .	—	1900	—	—	—	0.75

STEEL CONTAINING MANGANESE.

S.	P.	Si.	C.	Mn.		Strength at yield point ÷ 100.	Ultimate strength ÷ 100.	Young's Modulus ÷ 10^5.	Resilience to yield point.	Resilience to rupture ÷ 100.	Elongation per cent.
.06	.08	.37	.72	9.8	one test	—	1065	—	—	—	22.0
					another test	—	1190	—	—	—	28.9

* The samples here given are arranged in the order of ultimate strength. The table illustrates the great complexity of the problem of determining the effect of any given substance on the physical properties. It will be noticed that the specimens containing moderately large amounts of copper are low in ductility, — that high carbon or high sum of carbon and manganese generally gives high strength. The first specimen seems to indicate a weakening effect of silicon when a moderate amount of carbon is present. It has to be remembered that no table of this kind proves much unless nearly the same amount of work has been spent on the different specimens in the process of manufacture. Most of the lines give averages of a number of tests of similar steels. The table has been largely compiled from the Report of the Board on Testing Iron and Steel, Washington, 1881, and from results quoted in Howe's "Metallurgy of Steel."

† The strengths and elasticity data here given refer to bar or plate of moderate thickness, and are in pounds per square inch. Mild steel wire generally ranges in strength between 100000 and 200000 pounds per square inch, with an elongation of from 8 to 4 per cent. Thoroughly annealed wire does not differ greatly in strength from the data given in the table unless it has been subjected to special treatment for the purpose of producing high density and fine-grained structure. Drawing or stretching and subsequent rest tend to increase the Young's Modulus.

TABLE 73.

ELASTICITY AND STRENGTH OF IRON.*

Area of cross section of the bar in percentage of the area of the cross section of the pile.	Relative values of ultimate strength.	Relative values of the stress at the yield point.	
1	125	194	The variation of the yield point is not regular, and seems to have been much affected by the temperature of rolling.
2	112	170	
3	106	144	
4	104	140	
5	103	130	
7	101	114	
10	100	100	
15	98	92	

TABLE 74.

APPROXIMATE VARIATION OF THE STRENGTH OF BAR IRON, WITH VARIATION OF SECTION.†

Diameter in inches.	Strength per sq. in. in pounds.	Total strength of bar.	Diameter in inches.	Strength per sq. in. in pounds.	Total strength of bar.
2.2	59000	224000	1.1	54300	52000
2.1	58500	203000	1.0	54000	42000
2.0	58000	182000	0.9	53700	34000
1.9	57600	163000	0.8	53300	27000
1.8	57100	145000	0.7	53000	20000
1.7	56700	129000	0.6	52700	14900
1.6	56300	113000	0.5	52400	10300
1.5	55900	99000	0.4	52100	6600
1.4	55500	85000	0.3	51900	3700
1.3	55100	73000	0.2	51600	1600
1.2	54700	62000	0.1	51300	400

* This table was computed from the results published in the Report of the U. S. Board on Testing Iron and Steel, Washington, 1881, and shows approximately the relative effect of different amounts of reduction of section from the pile to the rolled bar. A reduction of the pile to 10 per cent of its original volume is taken as giving a strength of 100, and the others are expressed in the same units.

† The strength of bar iron may be taken as ranging from 15 per cent above to 15 per cent below the numbers here given, which represent the average of a large number of tests taken from various sources.

NOTES. — The stress at the yield point averages about 60 per cent of the ultimate strength, and generally lies between 50 and 70 per cent. The variation depends largely on the temperature of rolling if the iron be otherwise fairly pure.

According to the experiments of the U. S. Board for Testing Iron and Steel, above referred to, a bar of iron which has been subject to tensile stress up to its limit of strength gains from 10 to 20 per cent in strength if allowed to rest free from stress for eight days or more before breaking. The effect of stretching and subsequent rest in raising the elastic limit and tensile strength was discovered by Wöhler, and has been investigated by Bauschinger, who shows that the modulus of elasticity is also raised after rest. The strengthening effect of stretching with rest, or continuous very slowly increased loading, has been rediscovered by a number of experimenters.

EFFECT OF RELATIVE COMPOSITION ON THE STRENGTH OF ALLOYS OF COPPER, TIN, AND ZINC.*

TABLE 75. — Copper-Tin Alloys. (Bronzes.)

Percentage of copper.	Percentage of tin.	Tensile strength. (Pounds per square inch.)	Yield point. (Pounds per square inch.)	Crushing† strength. (Pounds per square inch.)	Percentage elongation.	Percentage compression.
100	00	28000	14000	42000	8.	44
95	5	31000	17000	46000	10.	41
90	10	29000	21000	54000	4.	31
85	15	33000	26000	74000	1.6	24
80	20	32000	28000	124000	0.5	14
75	25	18000	18000	150000	0.0	8
70	30	6500	6500	143000	0.0	2
65	35	2800	2800	75000	0.0	4

TABLE 76. — Copper-Zinc Alloys. (Brasses.

Percentage of copper.	Percentage of zinc.	Tensile strength. (Pounds per square inch.)	Yield point. (Pounds per square inch.)	Crushing‡ strength. (Pounds per square inch.)	Percentage elongation.
100	0	27000	14000	41000	7
95	5	28000	12000	28000	12
90	10	30000	10000	29000	18
85	15	32000	9000	33000	25
80	20	34000	8000	39000	33
75	25	37000	9000	46000	38
70	30	41000	10000	54000	38
65	35	46000	13000	63000	33
60	40	49000	17000	74000	19
55	45	44000	20000	90000	10
50	50	30000	24000	116000	4
45	55	14000	14000	126000	0

TABLE 77. — Copper-Zinc-Tin Alloys.§

Percentage of Copper.	Percentage of Zinc.	Percentage of Tin.	Tensile strength in pounds per sq. in.
45	50	5	15000
50	45	5	50000
50	40	10	15000
55	43	2	65000
	40	5	62000
	35	10	32500
	30	15	15000
60	37	3	60000
	35	5	52500
	30	10	40000
	20	20	10000
65	30	5	50000
	25	10	42000
	20	15	30000
	15	20	18000
	10	25	12000

Percentage of Copper.	Percentage of Zinc.	Percentage of Tin.	Tensile strength in pounds per sq. in.
70	25	5	45000
	20	10	44000
	15	15	37000
	10	20	30000
	5	25	24000
75	20	5	45000
	15	10	45000
	10	15	43000
	5	20	41000
80	15	5	45000
	10	10	45000
	5	15	47500
85	10	5	43500
	5	10	46500
90	5	5	42000

* These tables were compiled from the results published by the U. S. Board on Testing of Metals. The numbers refer to unwrought castings, and are subject to large variations for individual specimens.

† The crushing strengths here given correspond to 10 per cent compression for those cases where the total compression exceeds that amount.

‡ For crushing strength, 10 per cent compression was taken as standard.

§ This table covers the range of triple combinations of these three metals which contain alloys of useful strength and moderate ductility. The weaker cases here given, and those lying outside the range here taken, are generally weak and brittle. The absolute strength may of course be varied by the method of fusing and casting, and certainly can be greatly increased by working. The object of the table is to show relative values, and to give an idea of the strength of sound castings of these alloys.

ELASTIC MODULI.

Rigidity Modulus.*

Substance.	Modulus of Rigidity. Pounds per square inch ÷ 10^6.	Modulus of Rigidity. Grammes per square centimetre ÷ 10^6.	Authority.
Metals: —			
Aluminium	3.4–4.8	241–335	Thomson†–Katzenelsohn.
Brass and Bronze wire	4.6–5.8	320–410	Various.
Copper, drawn	5.6–6.7	393–473	Thomson.†
" "	5.0	352	Katzenelsohn.
German silver	6.2	432	"
" "	7.1	496	Gray.
Gold, pure	5.6	395	Katzenelsohn.
" "	4.0	281	Thomson.†
Iron, soft	9.6	671	Wertheim.
" drawn	10–14	700–800	Various.
Platinum	8.9	622	Thomson.†
"	9.4	663	Pisati.
Silver	3.8	270	Thomson.†
"	3.6	256	Pisati.
"	3.8	265	Baumeister.
Steel, cast	10.6	746	Wertheim.
" "	11.8	829	Pisati.
Tin	2.2	154	Kiewiet.
Zinc	5.1	360	Thomson.†
"	5.4	382	Kiewiet.
Glass	3.3	235	Wertheim.
"	3.9	273	Kowalski.
Stone: —			
Clay rock	2.5	177	Gray & Milne.
Granite	1.8	128	Gray & Milne.
Marble	1.7	119	Gray & Milne.
Slate	3.2	229	Gray & Milne.
Tuff	1.5	102	Gray & Milne.
Wood	.1–.17	7–12	Gray.

* The modulus of rigidity as used in this table may be shortly defined by the following equation: —

$$\text{Modulus of rigidity} = \frac{\text{Intensity of tangential stress.}}{\text{Distortion in radians.}}$$

To interpret the equation imagine a cube of the material, to four consecutive faces of which a tangential stress of uniform intensity is applied, the direction of the stress being opposite on adjacent faces. The modulus of rigidity is the number obtained by dividing the numerical value of the tangential stress per unit of area by the number representing the change of the angles on the nonstressed faces of the cube measured in radians.

† Lord Kelvin.

ELASTIC MODULI.

Young's Modulus.*

Substance.	Young's Modulus. Pounds per square inch $\div 10^6$.	Young's Modulus. Grammes per square centimetre $\div 10^6$.	Authority.
Metals: —			
Brass and bronze, cast	8.6–10	600–700	Various.
Brass, drawn	14–17	1000–1200	"
Copper, drawn	16–18	1150–1250	"
" annealed	15	1052	Wertheim.
German silver, drawn	17–20	1209–1400	Various.
Gold, drawn	12–14	813–980	"
" annealed	18	558	Wertheim.
Iron, cast	8–17†	550–1200	Various.
" wrought	24–30	1700–2100	"
Iron wire	" "	" "	"
Lead, cast or drawn	2.2–2.9	156–200	"
Palladium, soft	14	979	Wertheim.
" hard	17	1176	"
Platinum, drawn	23–26	1600–1700	Various.
" soft	22	1552	Wertheim.
Silver, drawn	10–10.7	700–750	Various.
Steel	23–30‡	1600–2100	"
" hard drawn	27–30	1900–2100	Various.
Tin	16	417	Wertheim.
Zinc	12–14	870–960	Various.
Bone . . . abt.	2.3	160	–
Carbon	2.2–3.6	151–255	Beetz.
Glass	8.6–11.4	600–800	Various.
Ice	7–10	500–700	"
Stone: —			
Clay rock	4.7	329	Gray & Milne.
Granite	5.9	416	Gray & Milne.
Marble	5.7	400	Gray & Milne.
Slate	9.8	686	Gray & Milne.
Tuff	2.7	189	Gray & Milne.
Whalebone . . . abt.	0.85	60	–
Wood	1.0–2.2	70–154	Various.

* The Young's Modulus of elasticity is used in connection with elongated bars or wires of elastic material. It is the ratio of the number representing the longitudinal stress per unit of area of transverse section to the number representing the elongation per unit of length produced by the stress, or: —

$$\text{Young's Modulus} = \frac{\text{Intensity of longitudinal stress.}}{\text{Elongation per unit length.}}$$

In the case of an isotropic substance the Young's Modulus is related to the elasticity of form (or rigidity modulus) and the elasticity of volume (or bulk modulus) in the manner indicated in the following equation: —

$$E = \frac{9nk}{3k+n}$$

where E is Young's Modulus, n the rigidity modulus and k the bulk modulus.

The bulk modulus is the ratio of the number expressing the intensity of a uniform normal stress applied all over the bounding surface of a body (solid, liquid or gas) to the number expressing the change of volume, per unit volume, produced by the stress.

† The modulus for cast iron varies greatly, not only for different specimens, but in the same specimen for different intensities of stress. It is diminished for tension stress by permanent elongation.

‡ See also Table 72.

ELASTIC MODULI.

TABLE 80. — Variation of the Rigidity of Metals with Temperature.*

The modulus of rigidity at temperature t is given by the equation $n_t = n_0 (1 + \alpha t + \beta t^2 + \gamma t^3)$.

Metal.	n_0	α	β	γ	Authority.
Brass	320×10^6	—.000455	—.00000136	—	K. & L.
"	265×10^7	—.002158	—.00000048	—.0000000032	Pisati.
Copper	397×10^6	—.002716	+.00000023	—.0000000047	"
"	390×10^6	—.000572	—.00000028	—	K. & L.
Iron	694×10^6	—.000483	—.00000012	—	"
"	811×10^6	—.000206	—.00000019	+.0000000011	Pisati.
Platinum	663×10^6	—.000111	—.00000050	+.0000000008	"
Silver	257×10^6	—.000387	—.00000038	—.0000000011	"
Steel	829×10^6	—.000187	—.00000059	+.0000000009	"

TABLE 81. — Ratio ρ of Transverse Contraction to Longitudinal Extension under Tensile Stress (Poisson's Ratio).

Name of substance.	Range of the value of ρ.	Mean of each range.	Final mean.	Authority.
Brass	— —	0.469	0.357	Everett.
"	0.340–0.500	0.420		Baumeister.
"	— —	0.387		Kirchhoff.
"	— —	0.325		Mallock.
"	— —	0.315		Wertheim.
"	— —	0.226		Littmann.
Copper	— —	0.348	0.340	Mallock.
"	0.224–0.441	0.332		Thomson.
Iron	— —	0.310	0.277	Everett.
"	— —	0.253		Mallock.
"	0.250–0.420	0.304		Baumeister.
"	0.214–0.268	0.243		Littmann.
Lead	— —	0.375	0.375	Mallock.
Steel, hard	0.293–0.295	0.294	0.295	Kirchhoff.
" "	0.275–0.328	0.294		Okatow.
" "	0.266–0.303	0.296		Schneebeli.
" soft	— —	0.304	0.299	Okatow.
" "	— —	0.306		Schneebeli.
" "	— —	0.253		Mallock.
" "	— —	0.333		Goetz & Kurz.
Zinc	0.180–0.230	0.205	0.205	Mallock.
Ebonite	— —	—	0.389	"
Ivory	— —	about	0.500	"
Paraffin	— —	—	0.500	"
Cork	— —	—	0.000	"
Caoutchouc (for small extensions)	0.370–0.640	0.505	0.502	Röntgen.
" " "	— —	0.500		Amagat.
Jelly	— —	0.500	0.500	Maurer.

Katzenelsohn gives the following values, together with the percentage variation δ between 0° and 100° C.

Substance.	ρ	δ
Aluminium	0.13	15.7
Brass	0.42	3.9
German silver	0.33	3.4
Gold	0.17	2.5
Iron	0.27	3.7
Platinum	0.16	5.5
Silver	0.37	12.2

* According to the experiments of Kohlrausch and Loomis (Pogg. Ann. vol. 141), and of Pisati (N. Cim. (3) vols. 4, 5).

ELASTICITY OF CRYSTALS.*

The formulæ were deduced from experiments made on rectangular prismatic bars cut from the crystal. These bars were subjected to cross bending and twisting and the corresponding Elastic Moduli deduced. The symbols $\alpha\ \beta\ \gamma$, $\alpha_1\ \beta_1\ \gamma_1$ and $\alpha_2\ \beta_2\ \gamma_2$ represent the direction cosines of the length, the greater and the less transverse dimensions of the prism with reference to the principal axis of the crystal. E is the modulus for extension or compression, and T is the modulus for torsional rigidity. The moduli are in grammes per square centimetre.

Barite.

$$\frac{10^{10}}{E} = 16.13\alpha^4 + 18.51\beta^4 + 10.42\gamma^4 + 2(38.79\beta^2\gamma^2 + 15.21\gamma^2\alpha^2 + 8.88\alpha^2\beta^2)$$

$$\frac{10^{10}}{T} = 69.52\alpha^4 + 117.66\beta^4 + 116.46\gamma^4 + 2(20.16\beta^2\gamma^2 + 85.29\gamma^2\alpha^2 + 127.35\alpha^2\beta^2)$$

Beryl (Emerald).

$$\frac{10^{10}}{E} = 4.325 \sin^4\phi + 4.619 \cos^4\phi + 13.328 \sin^2\phi \cos^2\phi$$

$$\frac{10^{10}}{T} = 15.00 - 3.675 \cos^4\phi_2 - 17.536 \cos^2\phi \cos^2\phi_1$$

where $\phi\ \phi_1\ \phi_2$ are the angles which the length, breadth, and thickness of the specimen make with the principal axis of the crystal.

Fluor spar.

$$\frac{10^{10}}{E} = 13.05 - 6.26\,(\alpha^4 + \beta^4 + \gamma^4)$$

$$\frac{10^{10}}{T} = 58.04 - 50.08\,(\beta^2\gamma^2 + \gamma^2\alpha^2 + \alpha^2\beta^2)$$

Pyrites.

$$\frac{10^{10}}{E} = 5.08 - 2.24\,(\alpha^4 + \beta^4 + \gamma^4)$$

$$\frac{10^{10}}{T} = 18.60 - 17.95\,(\beta^2\gamma^2 + \gamma^2\alpha^2 + \alpha^2\beta^2)$$

Rock salt.

$$\frac{10^{10}}{E} = 33.48 - 9.66\,(\alpha^4 + \beta^4 + \gamma^4)$$

$$\frac{10^{10}}{T} = 154.58 - 77.28\,(\beta^2\gamma^2 + \gamma^2\alpha^2 + \alpha^2\beta^2)$$

Sylvine.

$$\frac{10^{10}}{E} = 75.1 - 48.2\,(\alpha^4 + \beta^4 + \gamma^4)$$

$$\frac{10^{10}}{T} = 306.0 - 192.8\,(\beta^2\gamma^2 + \gamma^2\alpha^2 + \alpha^2\beta^2)$$

Topaz.

$$\frac{10^{10}}{E} = 4.341\alpha^4 + 3.460\beta^4 + 3.771\gamma^4 + 2\,(3.879\beta^2\gamma^2 + 28.56\gamma^2\alpha^2 + 2.39\alpha^2\beta^2)$$

$$\frac{10^{10}}{T} = 14.88\alpha^4 + 16.54\beta^4 + 16.45\gamma^4 + 30.89\beta^2\gamma^2 + 40.89\gamma^2\alpha^2 + 43.51\alpha^2\beta^2$$

Quartz.

$$\frac{10^{10}}{E} = 12.734\,(1-\gamma^2)^2 + 16.693\,(1-\gamma^2)\gamma^2 + 9.705\gamma^4 - 8.460\beta\gamma\,(3\alpha^2 - \beta^2)$$

$$\frac{10^{10}}{T} = 19.665 + 9.060\gamma_2^2 + 22.984\gamma^2\gamma_1^2 - 16.920\,[(\gamma\beta + \beta\gamma_1)\,(3\alpha\alpha_1 - \beta\beta_1) - \beta_2\gamma_2)]$$

* These formulæ are taken from Voigt's papers (Wied. Ann. vols. 31, 34, and 35).

ELASTICITY OF CRYSTALS.

Some particular values of the Elastic Moduli are here given. Under E are given moduli for extension or compression in the directions indicated by the subscripts and explained in the notes, and under T the moduli for torsional rigidities round the axes similarly indicated.

(a) REGULAR SYSTEM.*

Substance.	E_a	E_b	E_c	T_a	Authority.
Fluor spar . . .	1473×10^6	1008×10^6	910×10^6	345×10^6	Voigt.†
Pyrites	3530×10^6	2530×10^6	2310×10^6	1075×10^6	"
Rock salt	416×10^6	346×10^6	311×10^6	129×10^6	"
"	403×10^6	339×10^6	—	—	Koch.‡
Sylvine	401×10^6	209×10^6	—	—	"
"	372×10^6	196×10^6	—	655×10^5	Voigt.
Sodium chloride .	405×10^6	319×10^6	—	—	Koch.
Potash alum . . .	181×10^6	199×10^6	—	—	Beckenkamp.§
Chrome alum . .	161×10^6	177×10^6	—	—	"
Iron alum	186×10^6	—	—	—	"

(b) RHOMBIC SYSTEM.‖

Substance.	E_1	E_2	E_3	E_4	E_5	E_6	Authority.
Barite .	620×10^6	540×10^6	959×10^6	376×10^6	702×10^6	740×10^6	Voigt.
Topaz .	2304×10^6	2890×10^6	2652×10^6	2670×10^6	2893×10^6	3180×10^6	"

Substance.	$T_{12} = T_{21}$	$T_{13} = T_{31}$	$T_{23} = T_{32}$	Authority.
Barite	283×10^6	293×10^6	121×10^6	Voigt.
Topaz	1336×10^6	1353×10^6	1104×10^6	"

In the MONOCLINIC SYSTEM, Coromilas (Zeit. für Kryst. vol. 1) gives

$$\text{Gypsum} \begin{cases} E_{max} = 887 \times 10^6 \text{ at } 21.9^\circ \text{ to the principal axis.} \\ E_{min} = 313 \times 10^6 \text{ at } 75.4^\circ \text{ " " "} \end{cases}$$

$$\text{Mica} \begin{cases} E_{max} = 2213 \times 10^6 \text{ in the principal axis.} \\ E_{min} = 1554 \times 10^6 \text{ at } 45^\circ \text{ to the principal axis.} \end{cases}$$

In the HEXAGONAL SYSTEM, Voigt gives measurements on a beryl crystal (emerald). The subscripts indicate inclination in degrees of the axis of stress to the principal axis of the crystal.

$E_0 = 2165 \times 10^6$, $E_{45} = 1796 \times 10^6$, $E_{90} = 2312 \times 10^6$,

$T_0 = 667 \times 10^6$, $T_{90} = 883 \times 10^6$. The smallest cross dimension of the prism experimented on (see Table 82), was in the principal axis for this last case.

In the RHOMBOHEDRIC SYSTEM, Voigt has measured quartz. The subscripts have the same meaning as in the hexagonal system.

$E_0 = 1030 \times 10^6$, $E_{-45} = 1305 \times 10^6$, $E_{+45} = 850 \times 10^6$, $E_{90} = 785 \times 10^6$,

$T_0 = 508 \times 10^6$, $T_{90} = 348 \times 10^6$.

Baumgarten ¶ gives for calcspar

$E_0 = 501 \times 10^6$, $E_{-45} = 441 \times 10^6$, $E_{+45} = 772 \times 10^6$, $E_{90} = 790 \times 10^6$.

* In this system the subscript *a* indicates that compression or extension takes place along the crystalline axis, and distortion round the axis. The subscripts *b* and *c* correspond to directions equally inclined to two and normal to the third and equally inclined to all three axes respectively.

† Voigt, "Wied. Ann." vol. 31, 34-35.

‡ Koch, "Wied. Ann." vol. 18.

§ Beckenkamp, "Zeit. für Kryst." vol. 10.

‖ The subscripts 1, 2, 3 indicate that the three principal axes are the axes of stress; 4, 5, 6 that the axes of stress are in the three principal planes at angles of 45° to the corresponding axes.

¶ Baumgarten, "Pogg. Ann." vol. 152.

COMPRESSIBILITY OF GASES.*

These tables give the relative values of the product pv for different pressures and temperatures, and hence show the departure from Boyle's law. The pressures are in metres of mercury, or in atmospheres, the volume being arbitrary. The temperatures are in centigrade degrees.

TABLE 84. — Nitrogen.

Pressure in metres of mercury.	Relative values of pv at —				
	17°.7	30°.1	50°.4	75°.5	100°.1
30	2745	2875	3080	3330	3575
60	2740	2875	3100	3360	3610
100	2790	2930	3170	3445	3695
140	2890	3040	3275	3550	3820
180	3015	3150	3390	3675	3950
220	3140	3285	3530	3820	4090
260	3290	3440	3685	3975	4240
300	3450	3600	3840	4130	4400
320	3525	3675	3915	4210	4475

TABLE 85. — Hydrogen.

Pressure in metres of mercury.	Relative values of pv at —				
	17°.7	40°.4	60°.4	81°.1	100°.1
30	2830	3045	3235	3430	3610
60	2885	3110	3295	3500	3680
100	2985	3200	3400	3620	3780
140	3080	3300	3500	3710	3880
180	3185	3420	3620	3830	4010
220	3290	3520	3725	3930	4110
260	3400	3625	3830	4040	4220
300	3500	3730	3935	4140	4325
320	3550	3780	3990	4200	4385

TABLE 86. — Methane.

Pressure in metres of mercury.	Relative values of pv at —					
	14°.7	29°.5	40°.6	60°.1	79°.8	100°.1
30	2580	2745	2880	3100	–	–
60	2400	2590	2735	2995	3230	3460
100	2275	2480	2640	2935	3180	3435
140	2260	2480	2655	2940	3190	3460
180	2360	2560	2730	3015	3260	3525
220	2510	2690	2840	3125	3360	3625

TABLE 87. — Ethylene.

Pressure in metres of mercury.	Relative values of pv at —									
	16°.3	20°.3	30°.1	40°.0	50°.0	60°.0	70°.0	79°.9	89°.9	100°.0
30	1950	2055	2220	2410	2580	2715	2865	2970	3090	3225
60	810	900	1190	1535	1875	2100	2310	2500	2680	2860
90	1065	1115	1195	1325	1510	1710	1930	2160	2375	2565
120	1325	1370	1440	1540	1660	1780	1950	2115	2305	2470
150	1590	1625	1690	1785	1880	1990	2125	2250	2390	2540
180	1855	1890	1945	2035	2130	2225	2340	2450	2565	2700
210	2110	2145	2200	2285	2375	2470	2570	2680	2790	2910
240	2360	2395	2450	2540	2625	2720	2810	2910	3015	3125
270	2610	2640	2710	2790	2875	2965	3060	3150	3240	3345
300	2860	2890	2960	3040	3125	3215	3300	3380	3470	3560
320	3035	3065	3125	3200	3285	3375	3470	3545	3625	3710

* Tables 84-89 are from the experiments of Amagat; "Ann. de chim. et de phys.," 1881, or "Wied. Bieb.," 1881, p. 418.

COMPRESSIBILITY OF GASES.

TABLE 88. — Carbon Dioxide.

Pressure in metres of mercury.	Relative values of pv at —								
	18°.2	35°.1	40°.2	50°.0	60°.0	70°.0	80°.0	90°.0	100°.0
30	liquid	2360	2460	2590	2730	2870	2995	3120	3225
50	–	1725	1900	2145	2330	2525	2685	2845	2980
80	625	750	825	1200	1650	1975	2225	2440	2635
110	825	930	980	1090	1275	1550	1845	2105	2325
140	1020	1120	1175	1250	1360	1525	1715	1950	2160
170	1210	1310	1360	1430	1520	1645	1780	1975	2135
200	1405	1500	1550	1615	1705	1810	1930	2075	2215
230	1590	1690	1730	1800	1890	1990	2090	2210	2340
260	1770	1870	1920	1985	2070	2166	2265	2375	2490
290	1950	2060	2100	2170	2260	2340	2440	2550	2655
320	2135	2240	2280	2360	2440	2525	2620	2725	2830

TABLE 89. — Carbon Dioxide.*

Pressure in atmospheres.	Value of the ratio pv/p_1v_1 at —			
	50°	100°	200°	250°
0.725	1.0037	1.0021	1.0009	1.0003
1.440	1.0075	1.0048	1.0025	1.0015
2.850	1.1045	1.0087	1.0040	1.0020

TABLE 90. — Air, Oxygen, and Carbon Monoxide at Temperature between 18° and 22°.†

The pressure p is in metres of mercury; the product pv is simply relative.

Air.		Oxygen.		Carbon monoxide.	
p	pv	p	pv	p	pv
24.07	26968	24.07	26843	24.06	27147
34.90	26908	34.89	26614	34.91	27102
45.24	26791	–	–	45.25	27007
55.30	26789	55.50	26185	55.52	27025
64.00	26778	64.07	26050	64.00	27060
72.16	26792	72.15	25858	72.17	27071
84.22	26840	84.19	25745	84.21	27158
101.47	27041	101.46	25639	101.48	24420
133.89	27608	133.88	25671	133.90	28092
177.60	28540	177.58	25891	177.61	29217
214.54	29585	214.52	26536	214.54	30467
250.18	30572	–	–	250.18	31722
304.04	32488	303.03	28756	304.05	33919

* Similar experiments made on air showed the ratio pv/p_1v_1 to be practically constant.
† Amagat, "Compte Rendu," 1879.

RELATION BETWEEN PRESSURE, TEMPERATURE AND VOLUME OF SULPHUR DIOXIDE AND AMMONIA.*

TABLE 91. — Sulphur Dioxide.

Original volume 100000 under one atmosphere of pressure and the temperature of the experiments as indicated at the top of the different columns.

Pressure in Atmos.	Corresponding Volume for Experiments at Temperature —		
	58°.0	99°.6	183°.2
10	8560	9440	-
12	6360	7800	-
14	4040	6420	-
16	-	5310	-
18	-	4405	-
20	-	4030	-
24	-	3345	-
28	-	2780	3180
32	-	2305	2640
36	-	1935	2260
40	-	1450	2040
50	-	-	1640
60	-	-	1375
70	-	-	1130
80	-	-	930
90	-	-	790
100	-	-	680
120	-	-	545
140	-	-	430
160	-	-	325

Volume.	Pressure in Atmospheres for Experiments at Temperature —		
	58°.0	99°.6	183°.2
10000	-	9.60	-
9000	9.60	10.35	-
8000	10.40	11.85	-
7000	11.55	13.05	-
6000	12.30	14.70	-
5000	13.15	16.70	-
4000	14.00	20.15	-
3500	14.40	23.00	-
3000	-	26.40	29.10
2500	-	30.15	33.25
2000	-	35.20	40.95
1500	-	39.60	55.20
1000	-	-	76.00
500	-	-	117.20

TABLE 92. — Ammonia.

Original volume 100000 under one atmosphere of pressure and the temperature of the experiments as indicated at the top of the different columns.

Pressure in Atmos.	Corresponding Volume for Experiments at Temperature —		
	46°.6	99°.6	183°.6
10	9500	-	-
12.5	7245	7635	-
15	5880	6305	-
20	-	4645	4875
25	-	3560	3835
30	-	2875	3185
35	-	2440	2680
40	-	2080	2345
45	-	1795	2035
50	-	1490	1775
55	-	1250	1590
60	-	975	1450
70	-	-	1245
80	-	-	1125
90	-	-	1035
100	-	-	950

Volume.	Pressure in Atmospheres for Experiments at Temperature —			
	30°.2	46°.6	99°.6	183°.0
10000	8.85	9.50		-
9000	9.60	10.45		-
8000	10.40	11.50	12.00	-
7000	11.05	13.00	13.60	-
6000	11.80	14.75	15.55	-
5000	12.00	16.60	18.60	19.50
4000	-	18.35	22.70	24.00
3500	-	18.30	25.40	27.20
3000	-	-	29.20	31.50
2500	-	-	34.25	37.35
2000	-	-	41.45	45.50
1500	-	-	49.70	58.00
1000	-	-	59.65	93.60

* From the experiments of Roth, "Wied. Ann." vol. 11, 1880.

COMPRESSIBILITY AND BULK MODULI OF LIQUIDS.

Liquid.	Temp. C.	Compression per unit volume per atmo. × 10^6.	Pressure or range of pressure in atmospheres.	Authority.	Calculated values of bulk modulus in — Grammes per sq. cm.	Pounds per sq. in.
Acetone	14	110	8.7–35.4	Amagat	94 × 10^5	1.34 × 10^5
Benzene	16	90	8.12–37.2	"	115 "	1.64 "
"	15.4	87.1	1–4	Pagliani & Palazzo	119 "	1.69 "
"	50.1	111	1–4	"	93 "	1.32 "
Carbon bisulphide	0	78	—	Colladon & Sturm	133 "	1.89 "
" "	15	62.6	—	Quincke	165 "	2.35 "
" "	15.6	87.2	8–35	Amagat	119 "	1.69 "
" "	100	174	8–35	"	59 "	1.84 "
Chloroform . . .	8.5	62.5	1.267	Grassi	165 "	2.35 "
" . . .	9.2	62.6	4.247	"	165 "	2.35 "
" . . .	12	64.8	1.309	"	159 "	2.26 "
Ether	13	168	8–30	Amagat	61 "	0.87 "
"	99	555	8.6–13.5	"	18.6 "	0.26 "
"	99	523	8.6–36.5	"	19.8 "	0.28 "
"	63	300	8.57–22.29	"	34.4 "	0.49 "
"	63	293	8.57–34.33	"	35.3 "	0.50 "
"	25.4	190	8.46–34.22	"	54.4 "	0.77 "
Ethyl alcohol . .	10	94.5	1–2	Colladon & Sturm	109 "	1.55 "
" " . .	12	73.3	1–456	Tait	140 "	2.00 "
" " . .	14	101	8.5–37.12	Amagat	102 "	1.45 "
" " . .	28	86	150–200	Barus	120 "	1.71 "
" " . .	28	81	150–400	"	127 "	1.81 "
" " . .	65	110	150–200	"	94 "	1.34 "
" " . .	65	100	150–400	"	103 "	1.47 "
" " . .	100	168	150–200	"	61 "	0.87 "
" " . .	100	132	150–400	"	78 "	1.11 "
" " . .	185	320	150–200	"	32 "	0.46 "
" " . .	185	274	150–300	"	38 "	0.54 "
" " . .	185	245	150–400	"	42 "	0.60 "
" " . .	310	4200	150–200	"	2.5 "	0.036 "
" " . .	310	2200	150–300	"	4.7 "	0.067 "
" " . .	310	1530	150–400	"	6.7 "	0.095 "
Ethyl chloride . .	12.8	156	8.53–13.9	Amagat	66.3 "	0.94 "
" " . .	12.8	151	8.53–36.45	"	68.5 "	0.97 "
" " . .	61.5	256	12.65–34.36	"	40.3 "	0.57 "
" " . .	99	510	12.79–19.63	"	20.3 "	0.29 "
" " . .	99	495	12.79–34.47	"	20.9 "	0.30 "
Glycerine . . .	20.53	25.1	—	Quincke	411.2 "	5.85 "
Mercury	0	3.38	1–30	Colladon & Sturm	3058.0 "	43.5 "
"	0	3.92	—	Amagat	2629.0 "	37.4 "
Methyl alcohol . .	13.5	90.4	1.012	Grassi	114.5 "	1.63 "
" " . .	13.5	91.1	7.513	"	113.1 "	1.61 "
" " . .	100	221	8.68–37.32	Amagat	046.3 "	0.66 "
Nitric acid . . .	20.3	338.5	1–32	Colladon & Sturm	030.2 "	0.43 "
Oils: Almond . .	17	55.19	—	Quincke	187.7 "	2.67 "
Olive . . .	20.5	63.32	—	"	163.0 "	2.32 "
Paraffine .	14.84	62.69	—	De Metz	164.5 "	2.34 "
Petroleum .	16.5	69.58	—	Martini	148.3 "	2.11 "
Rock . . .	19.4	74.58	—	Quincke	138.4 "	1.97 "
Rape seed .	20.3	59.61	—	"	174.3 "	2.48 "
Turpentine .	19.7	79.14	—	"	130.7 "	1.86 "
Sulphur dioxide .	0	302.5	1–16	Colladon & Sturm	034.4 "	0.49 "
Toluene	10	79	—	De Heen	130.7 "	1.86 "
Xylene	10	73.8	—	"	140.0 "	1.99 "

COMPRESSIBILITY AND BULK MODULI OF LIQUIDS.

Liquid.	Temp. C.	Compression per unit volume per atmo. $\times 10^6$.	Pressure or range of pressure in atmospheres.	Authority.	Calculated values of bulk modulus in —	
					Grammes per sq. cm.	Pounds per sq. in.
Water, sea	12	44*	1	Tait	234.8 × 10^6	3.34 × 10^6
" pure	12	47*	1	"	220.0 "	3.13 "
" "	0	49.65	1–24	Colladon & Sturm .	208.0 "	2.96 "
" "	17.6	42.9	1–262	Amagat	241.1 "	3.43 "
" "	0	50.3	1–5	Pagliani & Vincentini	206.0 "	2.93 "
" "	10	47.0	1–5	"	220.0 "	3.13 "
" "	20	44.5	1–5	"	232.0 "	3.30 "
" "	30	42.5	1–5	"	243.2 "	3.46 "
" "	40	40.9	1–5	"	253.1 "	3.60 "
" "	50	39.7	1–5	"	260.1 "	3.70 "
" "	60	38.9	1–5	"	265.0 "	3.77 "
" "	70	39.0	1–5	"	264.3 "	3.76 "
" "	80	39.6	1–5	"	260.8 "	3.71 "
" "	90	40.2	1–5	"	257.3 "	3.66 "
" "	100	41.0	1–5	"	252.4 "	3.59 "

COMPRESSIBILITY AND BULK MODULI OF SOLIDS.

Solid.	Compression per unit volume per atmo. $\times 10^6$.	Authority.	Calculated values of bulk modulus in —	
			Grammes per sq. cm.	Pounds per sq. in.
Crystals: Barite	1.93	Voigt . .	535 × 10^6	7.61 × 10^6
Beryl	0.747	" . .	1384 "	19.68 "
Fluorspar	1.20	" . .	860 "	12.24 "
Pyrites	1.14	" . .	906 "	12.89 "
Quartz	2.67	" . .	387 "	5.50 "
Rock salt	4.2†	" . .	246 "	3.50 "
Sylvine	7.45†	" . .	138 "	1.97 "
Topaz	0.61	" . .	1694 "	24.11 "
Tourmaline	0.113	" . .	9140 "	130.10 "
Brass	0.95	Amagat .	1090 "	15.48 "
Copper	0.86	Buchanan	1202 "	17.10 "
Delta metal	1.02	Amagat .	1012 "	14.41 "
Lead	2.76	" .	374 "	5.32 "
Steel	0.68	" .	1518 "	21.61 "
Glass	2.2–2.9	" .	405 "	5.76 "

* Tait finds for fresh water the value .0072 ($1 - 0.034p$) and for sea water .00666 ($1 - 0.034p$) where p is the pressure in tons per square inch. The range of variation of p was from 1 to 3 tons.

† Röntgen and Schneider by piezometric experiments obtained 5.0×10^{-6} for rock salt and 5.6×10^{-6} for sylvine (Wied. Ann., vol. 31).

Table 95.

DENSITY OR MASS IN GRAMMES PER CUBIC CENTIMETRE AND POUNDS PER CUBIC FOOT OF VARIOUS SOLIDS.*

Substance.	Grammes per cubic centimetre.	Pounds per cubic foot.	Substance.	Grammes per cubic centimetre.	Pounds per cubic foot.
Agate	2.5–2.7	156–168	Gas carbon	1.88	119
Alabaster:			Glass:		
Carbonate	2.69–2.78	168–173	Common	2.4–2.8	150–175
Sulphate	2.26–2.32	141–145	Flint	2.9–4.5	180–280
Alum, potash	1.7	106	Glauber's salt	1.4–1.5	87–93
Amber	1.06–1.11	66–69	Glue	1.27	80
Anthracite	1.4–1.8	87–112	Gneiss	2.4–2.7	150–168
Apatite	3.16–3.22	197–201	Granite	2.5–3.0	156–187
Aragonite	3.0	187	Graphite	1.9–2.3	120–140
Arsenic	5.7–5.72	356–358	Gravel	1.2–1.8	94–112
Asbestos	2.0–2.8	125–175	Gray copper ore	4.4–5.4	275–335
Asphaltum	1.1–1.2	69–75	Green stone	2.9–3.0	180–185
Barite	4.5	281	Gum arabic	1.3–1.4	80–85
Basalt	2.7–3.1	168–193	Gunpowder:		
Beeswax	0.96–0.97	60–61	Loose	0.9	56
Bole	2.2–2.5	137–156	Tamped	1.75	109
Bone	1.7–2.0	106–125	Gypsum, burnt	1.81	113
Boracite	2.9–3.0	181–187	Hornblende	3.0	187
Borax	1.7–1.8	106–112	Ice	0.88–0.91	55–57
Borax glass	2.6	162	Iodine	4.95	309
Boron	2.68–2.69	167–168	Ivory	1.83–1.92	114–120
Brick	2.0–2.2	125–137	Kaolin	2.2	137
Butter	0.86–0.87	53–54	Lava:		
Calamine	4.1–4.5	255–280	Basaltic	2.8–3.0	175–185
Calcspar	2.6–2.8	162–175	Trachytic	2.0–2.7	125–168
Carbon.			Lead acetate	2.4	150
See Graphite, etc.			Leather:		
Caoutchouc	0.92–0.99	57–62	Dry	0.86	54
Celestine	3.9	243	Greased	1.02	64
Cement:			Lime:		
Pulverized loose	1.15–1.7	72–105	Mortar	1.65–1.78	103–111
Pressed	1.85	115	Slaked	1.3–1.4	81–87
Set	2.7–3.0	168–187	Lime	2.3–3.2	144–200
Cetin	0.88–0.94	55–59	Limestone	2.46–2.86	154–178
Chalk	1.9–2.8	118–175	Litharge:		
Charcoal:			Artificial	9.3–9.4	580–585
Oak	0.57	35	Natural	7.8–8.0	489–492
Pine	0.28–0.44	17.5–27.5	Magnesia	3.2	200
Chrome yellow	6.00	374	Magnesite	3.0	187
Cinnabar	8.12	507	Magnetite	4.9–5.2	306–324
Clay	1.8–2.6	122–162	Malachite	3.7–4.1	231–256
Clayslate	2.8–2.9	175–180	Manganese:		
Coal, soft	1.2–1.5	75–94	Red ore	3.46	216
Cobaltite	6.4–7.3	400–455	Black ore	3.9–4.1	243–256
Cocoa butter	0.89–0.91	56–57	Marble	2.5–2.8	157–177
Coke	1.0–1.7	62–105	Marl	1.6–2.5	100–156
Copal	1.04–1.14	65–71	Masonry	1.85–2.3	116–144
Corundum	3.9–4.0	245–250	Meerschaum	.99–1.28	61.8–79.9
Diamond	3.5–3.6	220–225	Melaphyre	2.6	162
Anthracitic	1.66	104	Mica	2.6–3.2	165–200
Carbonado	3.01–3.25	188–203	Mortar	1.75	109
Diorite	2.8–3.1	175–193	Mud	1.6	102
Dolomite	3.8–2.9	175–181	Nitroglycerine	1.6	99
Earth, dry	1.6–1.9	100–120	Ochre	3.5	218
Ebonite	1.15	72	Opal	2.2	137
Emery	4.0	250	Orpiment	3.4–3.5	212–218
Epsom salts:			Paper	0.7–1.15	44–72
Crystalline	1.7–1.8	106–112	Paraffin	0.87–0.91	54–57
Anhydrous	2.6	162	Peat	0.84	52
Feldspar	2.53–2.58	158–161	Phosphorus, white	1.82	114
Flint	2.63	164	Pitch	1.07	67
Fluor spar	3.14–3.18	196–198	Porcelain	2.3–2.5	143–156
Gabronite	2.9–3.0	181–187	Porphyry	2.6–2.9	162–181
Gamboge	1.2	75	Potash	2.26	141
Galena	7.3–7.6	460–470	Pyrites	4.9–5.2	306–324
Garnet	3.6–3.8	230–335	Pyrolusite	3.7–4.6	231–287

* For metals, see Table 97.

DENSITY OF VARIOUS SOLIDS.

Substance.	Grammes per cubic centimetre.	Pounds per cubic foot.	Substance.	Grammes per cubic centimetre.	Pounds per cubic foot.
Pumice stone	0.37–0.9	23–56	Soapstone, Steatite	2.6–2.8	162–175
Quartz	2.65	165	Soda:		
Resin	1.07	67	Roasted	2.5	156
Rock crystal	2.6	162	Crystalline	1.45	90
Rock salt	2.28–2.41	142–150	Spathic iron ore	3.7–3.9	231–243
Sal ammoniac	1.5–1 6	94–100	Starch	1.53	95
Saltpetre	1.95–2.08	122–130	Stibnite	4.6–4.7	287–293
Sand:			Strontianite	3.7	231
Dry	1.40–1.65	87–103	Syenite	2.6–2.8	162
Damp	1.90–2.05	119–128	Sugar	1.61	100
Sandstone	2.2–2.5	137–156	Talc	2.7	168
Selenium	4.2–4.8	262–300	Tallow	.91–.97	570–605
Serpentine	2.43–2.66	152–166	Tellurium	6.38–6.42	398–401
Shale	2.6	162	Tile	1.4–2.3	87–143
Silicon	2.0–2.5	125–156	Tinstone	6.4–7.0	399–437
Siliceous earth	2.66	166	Topaz	3.5–3.6	219–223
Slag, furnace	2.5–3.0	156–187	Tourmaline	2.94–3.24	183–202
Slate	2.6–2.7	162–168	Trachyte	2.7–2.8	168–175
Snow, loose	0.125	7.8	Trap	2.6–2.7	162–170

TABLE 96.

DENSITY OR MASS IN GRAMMES PER CUBIC CENTIMETRE AND POUNDS PER CUBIC FOOT OF VARIOUS ALLOYS (BRASSES AND BRONZES).

Alloy.	Grammes per cubic centimetre.	Pounds per cubic foot.
Brasses: Yellow, 70Cu + 30Zn, cast	8.44	527
" " " rolled	8.56	534
" " " drawn	8.70	542
" Red, 90Cu + 10Zn	8.60	536
" White, 50Cu + 50Zn	8.20	511
Bronzes: 90Cu + 10Sn	8.78	548
" 85Cu + 15Sn	8.89	555
" 80Cu + 20Sn	8.74	545
" 75Cu + 25Sn	8.83	551
German Silver: Chinese, 26.3Cu + 36.6Zn + 36.8 Ni	8.30	518
" " Berlin (1) 52Cu + 26Zn + 22Ni	8.45	527
" " " (2) 59Cu + 30Zn + 11Ni	8.34	520
" " " (3) 63Cu + 30Zn + 6Ni	8.30	518
" " Nickelin	8.77	547
Lead and Tin: 87.5Pb + 12.5Sn	10.60	661
" " " 84Pb + 16Sn	10.33	644
" " " 77.8Pb + 22.2Sn	10.05	627
" " " 63.7Pb + 36.3Sn	9.43	588
" " " 46.7Pb + 53.3Sn	8.73	545
" " " 30.5Pb + 69.5Sn	8.24	514
Bismuth, Lead, and Tin: 53Bi + 40Pb + 7Cd	10.56	659
Wood's Metal: 50Bi + 25Pb + 12.5Cd + 12.5Sn	9.70	605
Cadmium and Tin: 32Cd + 68Sn	7.70	480
Gold and Copper: 98Au + 2Cu	18.84	1176
" " " 96Au + 4Cu	18.36	1145
" " " 94Au + 6Cu	17.95	1120
" " " 92Au + 8Cu	17.52	1093
" " " 90Au + 10Cu	17.16	1071
" " " 88Au + 12Cu	16.81	1049
" " " 86Au + 14Cu	16.47	1027
Aluminium and Copper: 10Al + 90Cu	7.69	480
" " " 5Al + 95Cu	8.37	522
" " " 3Al + 97Cu	8.69	542
Aluminium and Zinc: 91Al + 9Zn	2.80	175
Platinum and Iridium: 90Pt + 10Ir	21.62	1348
" " " 85Pt + 15Ir	21.62	1348
" " " 66.67Pt + 33.33Ir	21.87	1364
" " " 5Pt + 95Ir	22.38	1396

Table 97.

DENSITY OR MASS IN GRAMMES PER CUBIC CENTIMETRE AND POUNDS PER CUBIC FOOT OF THE METALS.*

When the value is taken from a particular authority that authority is given, but in most cases the extremes or average from a number of authorities are given.

Metal.	Physical state.	Grammes per cubic centimetre.	Pounds per cubic foot.	Temp. C.†	Authority.
Aluminium	Cast	2.56–2.58	160–161		
"	Wrought	2.65–2.80	165–175		
Antimony	Solid	6.70–6.72	418–419		
"	Amorphous	About 6.22	388		
Barium	—	3.75–4.00	234–250		
Bismuth	Solid	9.70–9.90	605–618		
"	"	9.673	604	271	Vincentini and Omodei.
"	Liquid	10.004	624	271	
Cadmium	Cast	8.54–8.57	533–535		
"	Wrought	8.670	541		
"	Solid	8.366	522	318	Vincentini and Omodei.
"	Liquid	7.989	498	318	
Caesium	—	1.88–1.90	117		
Calcium	—	1.580	98.6		
Cerium	—	6.62–6.72	475–482		
Chromium	—	6.52–6.73	407–420		
Cobalt	Cast	8.50–8.70	530–542		
"	Wrought	9.100	563		
Columbium	Liquid	7.10–7.40	443–462		
Copper	Cast	8.80–8.95	549–558		
"	Wrought	8.85–8.95	552–558		
"	Liquid	8.217	513		Roberts & Wrightson.
Didymium	—	6.540	408		
Gallium	—	5.930	370	24	Lecoq de Boisbaudran.
Germanium	—	5.460	341	20	Winkler.
Glucinium	—	1.86–2.06	116–127		
Gold	Cast	19.26–19.34	1202–1207		
"	Wrought	19.33–19.34	1207		
Indium	—	7.27–7.42	454–463		
Iridium	—	21.78–22.42	1359–1399		
Iron	Gray cast	7.03–7.13	439–445		
"	White cast	7.58–7.73	473–482		
"	Wrought	7.80–7.90	485–493		
"	Liquid	6.880	429		Roberts & Wrightson.
Lanthanum	—	6.05–6.16	377–384		Hildebrand & Norton.
Lead	Cast	11.340	708	24	Reich.
"	Wrought	11.360	709	24	"
"	Solid	11.005	686	325	Vincentini and Omodei.
"	Liquid	10.645	664	325	
Lithium	—	0.590	39		
Magnesium	—	1.69–1.75	105–109		
Manganese	—	6.86–8.03	428–501		
"	—	Av. abt. 7.4	462		
Mercury	—	13.596	848		
Molybdenum	—	8.40–8.60	524–536		
Nickel	—	8.30–8.90	517–555		
Osmium	—	21.40–22.40	1335–1398		
Palladium	—	11.00–12.00	686–749		
Platinum	—	21.20–21.70	1322–1354		
Potassium	Solid	0.86–0.88	54–55		
"	Solid	0.8510	53.7	62.1	Vincentini and Omodei.
"	Liquid	0.8298	53.8	62.1	
Rhodium	—	11.00–12.10	686–755		
Ruthenium	—	11.00–11.40	686–711		
Silver	Cast	10.40–10.50	649–655		
"	Wrought	10.55–10.57	658–659		
"	Liquid	9.500	593		Roberts & Wrightson.

* This table has been to a large extent compiled from Clark's "Constants of Nature," and Landolt & Börnstein's "Phys. Chem. Tab."

† When the temperature is not given, ordinary atmospheric temperature is to be understood.

DENSITY OR MASS IN GRAMMES PER CUBIC CENTIMETRE AND POUNDS PER CUBIC FOOT OF THE METALS.

Metal.	Physical state.	Grammes per cubic centimetre.	Pounds per cubic foot.	Temp. C.*	Authority.
Sodium	—	0.97–0.99	605–618		
"	Solid . . .	0.9519	59.4	97.6	Vincentini and Omodei.
"	Liquid . . .	0.9287	58.0	97.6	
"	At boiling pt.	0.7414	46.3	·	Ramsay.
Strontium . . .	—	2.50–2.58	156–161		Matthieson.
Thallium . . .	—	11.8–11.9	736–742		
Tin	Cast. . . .	7.290	455		Matthieson.
"	Wrought . .	7.300	455		
"	Crystallized .	6.97–7.18	435–448		
"	Solid . . .	7.1835	454	226	Vincentini and Omodei.
"	Liquid . . .	6.988	436	226	
Titanium † . . .	—	5.300	341		
Thorium ‡ . . .	—	9.4–10.1	587–630		
Tungsten . . .	—	19.120	1193		Roscoe.
Uranium . . .	—	18.33–18.65	1143–1163		
Zinc	Cast . . .	7.04–7.16	439–447		
"	Wrought . .	7.190	449		
"	Liquid . . .	6.480	404		Roberts & Wrightson.
Zirconium . . .	—	4.140	258		Froost.

MASS IN GRAMMES PER CUBIC CENTIMETRE AND IN POUNDS PER CUBIC FOOT OF DIFFERENT KINDS OF WOOD.

The wood is supposed to be seasoned and of average dryness.

Wood.	Grammes per cubic centimetre.	Pounds per cubic foot.	Wood.	Grammes per cubic centimetre.	Pounds per cubic foot.
Alder	0.42–0.68	26–42	Greenheart	0.93–1.04	58–65
Apple	0.66–0.84	41–52	Hazel	0.60–0.80	37–49
Ash	0.65–0.85	40–53	Hickory	0.60–0.93	37–58
Basswood. See Linden.			Iron-bark	1.03	64
Beech	0.70–0.90	43–56	Laburnum	0.92	57
Blue gum	0.84	52	Lancewood	0.68–1.00	42–62
Birch	0.51–0.77	32–48	Lignum vitæ	1.17–1.33	73–83
Box	0.95–1.16	59–72	Linden or Lime-tree . .	0.32–0.59	20–37
Bullet tree	1.05	65	Locust	0.67–0.71	42–44
Butternut	0.38	24	Mahogany, Honduras .	0.56	35
Cedar	0.49–0.57	30–35	" Spanish . .	0.85	53
Cherry	0.70–0.90	43–56	Maple	0.62–0.75	39–47
Cork	0.22–0.26	14–16	Oak	0.60–0.90	37–56
Ebony	1.11–1.33	69–83	Pear-tree	0.61–0.73	38–45
Elm	0.54–0.60	34–37	Plum-tree	0.66–0.78	41–49
Fir or Pine, American			Poplar	0.35–0.5	22–31
White	0.35–0.50	22–31	Satinwood	0.95	59
" Larch . .	0.50–0.56	31–35	Sycamore	0.40–0.60	24–37
" Pitch . .	0.83–0.85	52–53	Teak, Indian	0.66–0.88	41–55
" Red . .	0.48–0.70	30–44	" African	0.98	61
" Scotch .	0.43–0.53	27–33	Walnut	0.64–0.70	40–43
" Spruce .	0.48–0.70	30–44	Water gum	1.00	62
" Yellow .	0.37–0.60	23–37	Willow	0.40–0.60	24–37

* When the temperature is not given, ordinary atmospheric temperature is to be understood.
† The density of titanium is inferential, and actual determination a year or two ago gave a lower value.
‡ The lower value for thorium represents impure material.

DENSITY OF LIQUIDS.

Density or mass in grammes per cubic centimetres and in pounds per cubic foot of various liquids.

Liquid.	Grammes per cubic centimetre.	Pounds per cubic foot.	Temp. C.
Acetone	0.792	49.4	0°
Alcohol, ethyl	0.791	49.4	0
" methyl	0.810	50.5	0
" proof spirit	0.916	57.2	0
Anilin	1.035	64.5	0
Benzene	0.899	56.1	0
Bromine	3.187	199.0	0
Carbolic acid (crude)	0.950–0.965	59.2–60.2	15
Carbon disulphide	1.293	80.6	15
Chloroform	1.480	92.3	18
Ether	0.736	45.9	0
Glycerine	1.260	78.6	0
Mercury	13.596	836.0	0
Naphtha (wood)	0.848–0.810	52.9–50.5	0
Naphtha (petroleum ether)	0.665	41.5	15
Oils: Amber	0.800	49.9	15
Anise-seed	0.996	61.1	16
Camphor	0.910	56.8	—
Castor	0.969	60.5	15
Cocoanut	0.925	57.7	15
Cotton seed	0.926	60.2	16
Creosot	1.040–1.100	64.9–68.6	15
Lard	0.920	57.4	15
Lavender	0.877	54.7	16
Lemon	0.844	52.7	16
Linseed (boiled)	0.942	58.8	15
Mineral (lubricating)	0.900–0.925	56.2–57.7	20
Olive	0.918	57.3	15
Palm	0.905	56.5	15
Pine	0.850–0.860	53.0–54.0	15
Poppy	0.924	57.7	—
Rapeseed (crude)	0.915	57.1	15
" (refined)	0.913	57.0	15
Resin	0.955	59.6	15
Train *or* Whale	0.918–0.925	57.3–57.7	15
Turpentine	0.873	54.2	16
Valerian	0.965	60.2	16
Petroleum	0.878	54.8	0
" (light)	0.795–0.805	49.6–50.2	15
Pyroligneous acid	0.800	49.9	0
Sea water	1.025	64.0	15
Soda lye	1.210	75.5	17
Water	1.000	62.4	4

DENSITY OF GASES.

The following table gives the specific gravity of gases at 0° C. and 76 centimetres pressure relative to air at 0° and 76 centimetres pressure, together with their mass in grammes per cubic centimetre and in pounds per cubic foot.

Gas.		Sp. gr.	Grammes per cubic centimetre.	Pounds per cubic foot.
Air		1.000	0.001293	0.08071
Ammonia		0.597	0.000770	0.04807
Carbon dioxide		1.529	0.001974	0.12323
Carbon monoxide		0.967	0.001234	0.07704
Chlorine		2.422	0.003133	0.19559
Coal gas	from	0.320	0.000414	0.02583
	to	0.740	0.000957	0.05973
Cyanogen		1.806	0.002330	0.14546
Hydrofluoric acid		2.370	0.002937	0.18335
Hydrochloric acid		1.250	0.001616	0.10088
Hydrogen		0.0696	0.000090	0.00562
Hydrogen sulphide		1.191	0.001476	0.09214
Marsh gas		0.559	0.000727	0.04538
Nitrogen		0.972	0.001257	0.07847
Nitric oxide, NO		1.039	0.001343	0.08384
Nitrous oxide, N_2O		1.527	0.001970	0.12298
Oxygen		1.105	0.001430	0.08927
Sulphur dioxide		2.247	0.002785	0.17386
Steam at 100° C.		0.469	0.000581	0.03627

TABLE 101.

DENSITY OF AQUEOUS SOLUTIONS.*

The following table gives the density of solutions of various salts in water. The numbers give the weight in grammes per cubic centimetre. For brevity the substance is indicated by formula only.

Substance.	Weight of the dissolved substance in 100 parts by weight of the solution.									Temp. C.	Authority.
	5	10	15	20	25	30	40	50	60		
K_2O	1.047	1.098	1.153	1.214	1.284	1.354	1.503	1.659	1.809	15.	Schiff.
KOH	1.040	1.082	1.027	1.076	1.229	1.286	1.410	1.538	1.666	15.	"
Na_2O	1.073	1.144	1.218	1.284	1.354	1.421	1.557	1.689	1.829	15.	"
$NaOH$	1.058	1.114	1.169	1.224	1.279	1.331	1.436	1.539	1.642	15.	"
NH_3	0.978	0.949	0.940	0.924	0.909	0.896	–	–	–	16.	Carius.
NH_4Cl	1.015	1.030	1.044	1.058	1.072	–	–	–	–	15.	Gerlach.
KCl	1.031	1.065	1.099	1.135	–	–	–	–	–	15.	"
$NaCl$	1.035	1.072	1.110	1.150	1.191	–	–	–	–	15.	"
$LiCl$	1.029	1.057	1.085	1.116	1.147	1.181	1.255	–	–	15.	"
$CaCl_2$	1.041	1.086	1.132	1.181	1.232	1.286	1.402	–	–	15.	"
$CaCl_2 + 6H_2O$	1.019	1.040	1.061	1.083	1.105	1.128	1.176	1.225	1.276	18.	Schiff.
$AlCl_3$	1.035	1.072	1.111	1.153	1.196	1.241	1.340	–	–	15.	Gerlach.
$MgCl_2$	1.041	1.085	1.130	1.177	1.226	1.278	–	–	–	15.	"
$MgCl_2+6H_2O$	1.014	1.032	1.049	1.067	1.085	1.103	1.141	1.183	1.222	24.	Schiff.
$ZnCl_2$	1.043	1.089	1.135	1.184	1.236	1.289	1.417	1.563	1.737	19.5	Kremers.
$CdCl_2$	1.043	1.087	1.138	1.193	1.254	1.319	1.469	1.653	1.887	19.5	"
$SrCl_2$	1.044	1.092	1.143	1.198	1.257	1.321	–	–	–	15.	Gerlach.
$SrCl_2 + 6H_2O$	1.027	1.053	1.082	1.111	1.042	1.174	1.242	1.317	–	15.	"
$BaCl_2$	1.045	1.094	1.147	1.205	1.269	–	–	–	–	15.	"
$BaCl_2 + 2H_2O$	1.035	1.075	1.119	1.166	1.217	1.273	–	–	–	21.	Schiff.
$CuCl_2$	1.044	1.091	1.155	1.221	1.291	1.360	1.527	–	–	17.5	Franz.
NCl_2	1.048	1.098	1.157	1.223	1.299	–	–	–	–	17.5	"
$HgCl_2$	1.041	1.092	–	–	–	–	–	–	–	20.	Mendelejeff.
Fe_2Cl_6	1.041	1.086	1.130	1.179	1.232	1.290	1.413	1.545	1.668	17.5	Hager.
$PtCl_4$	1.046	1.097	1.153	1.214	1.285	1.362	1.546	1.785	–	–	Precht.
$SnCl_2 + 2H_2O$	1.032	1.067	1.104	1.143	1.185	1.229	1.329	1.444	1.580	15.	Gerlach.
$SnCl_4 + 5H_2O$	1.029	1.058	1.089	1.122	1.157	1.193	1.274	1.365	1.467	15.	"
$LiBr$	1.033	1.070	1.111	1.154	1.202	1.252	1.366	1.498	–	19.5	Kremers.
KBr	1.035	1.073	1.114	1.157	1.205	1.254	1.364	–	–	19.5	"
$NaBr$	1.038	1.078	1.123	1.172	1.224	1.279	1.408	1.563	–	19.5	"
$MgBr_2$	1.041	1.085	1.135	1.189	1.245	1.308	1.449	1.623	–	19.5	"
$ZnBr_2$	1.043	1.091	1.194	1.202	1.263	1.328	1.473	1.648	1.873	19.5	"
$CdBr_2$	1.041	1.088	1.139	1.197	1.258	1.324	1.479	1.678	–	19.5	"
$CaBr_2$	1.042	1.087	1.137	1.192	2.250	1.313	1.459	1.639	–	19.5	"
$BaBr_2$	1.043	1.090	1.142	1.199	1.260	1.327	1.483	1.683	–	19.5	"
$SrBr_2$	1.043	1.089	1.140	1.198	1.260	1.328	1.489	1.693	1.953	19.5	"
KI	1.036	1.076	1.118	1.164	1.216	1.269	1.394	1.544	1.732	19.5	"
LiI	1.036	1.077	1.122	1.170	1.222	1.278	1.412	1.573	1.775	19.5	"
NaI	1.038	1.080	1.126	1.177	1.232	1.292	1.430	1.598	1.808	19.5	"
ZnI_2	1.043	1.089	1.138	1.194	1.253	1.366	1.418	1.648	1.873	19.5	"
CdI_2	1.042	1.086	1.136	1.192	1.251	1.317	1.474	1.678	–	19.5	"
MgI_2	1.041	1.086	1.137	1.192	1.252	1.318	1.472	1.666	1.913	19.5	"
CaI_2	1.042	1.088	1.138	1.196	1.258	1.319	1.475	1.663	1.908	19.5	"
SrI_2	1.043	1.089	1.140	1.198	1.260	1.328	1.489	1.693	1.953	19.5	"
BaI_2	1.043	1.089	1.141	1.199	1.263	1.331	1.493	1.702	1.968	19.5	"
$NaClO_3$	1.035	1.068	1.106	1.145	1.188	1.233	1.329	–	–	19.5	"
$NaBrO_3$	1.039	1.081	1.127	1.176	1.229	1.287	–	–	–	19.5	"
KNO_3	1.031	1.064	1.099	1.135	–	–	–	–	–	15.	Gerlach.
$NaNO_3$	1.031	1.065	1.101	1.140	1.180	1.222	1.313	1.416	–	20.2	Schiff.
$AgNO_3$	1.044	1.090	1.140	1.195	1.255	1.322	1.479	1.675	1.918	15.	Kohlrausch.

* Compiled from two papers on the subject by Gerlach in the "Zeit. für Anal. Chim.," vols. 8 and 27.

DENSITY OF AQUEOUS SOLUTIONS.

Substance.	Weight of the dissolved substance in 100 parts by weight of the solution.									Temp. C.	Authority.
	5	10	15	20	25	30	40	50	60		
NH_4NO_3	1.020	1.041	1.063	1.085	1.107	1.131	1.178	1.229	1.282	17.5	Gerlach.
$ZnNO_3$	1.048	1.095	1.146	1.201	1.263	1.325	1.456	1.597	–	17.5	Franz.
$ZnNO_3+6H_2O$	–	1.054	–	1.113	–	1.178	1.250	1.329	–	14.	Oudemans.
$Ca(NO_3)_2$	1.037	1.075	1.118	1.162	1.211	1.260	1.367	1.482	1.604	17.5	Gerlach.
$Cu(NO_3)_2$	1.044	1.093	1.143	1.203	1.263	1.328	1.471	–	–	17.5	Franz.
$Sr(NO_3)_2$	1.039	1.083	1.129	1.179	–	–	–	–	–	19.5	Kremers.
$Pb(NO_3)_2$	1.043	1.091	1.143	1.199	1.262	1.332	–	–	–	17.5	Gerlach.
$Cd(NO_3)_2$	1.052	1.097	1.150	1.212	1.283	1.355	1.536	1.759	–	17.5	Franz.
$Co(NO_3)_2$	1.045	1.090	1.137	1.192	1.252	1.318	1.465	–	–	17.5	“
$Ni(NO_3)_2$	1.045	1.090	1.137	1.192	1.252	1.318	1.465	–	–	17.5	“
$Fe_2(NO_3)_6$	1.039	1.076	1.117	1.160	1.210	1.261	1.373	1.496	1.657	17.5	“
$Mg(NO_3)_2+6H_2O$	1.018	1.038	1.060	1.082	1.105	1.129	1.179	1.232	–	21	Schiff.
$Mn(NO_3)_2+6H_2O$	1.025	1.052	1.079	1.108	1.138	1.169	1.235	1.307	1.386	8	Oudemans.
K_2CO_3	1.044	1.092	1.141	1.192	1.245	1.300	1.417	1.543	–	15	Gerlach.
$K_2CO_3 + 2H_2O$	1.037	1.072	1.110	1.150	1.191	1.233	1.320	1.415	1.511	15.	“
$Na_2CO_3 10H_2O$	1.019	1.038	1.057	1.077	1.098	1.118	–	–	–	15.	“
$(NH_4)_2SO_4$	1.027	1.055	1.084	1.113	1.142	1.170	1.226	1.287	–	19.	Schiff.
$Fe_2(SO_4)_3$	1.045	1.096	1.150	1.207	1.270	1.336	1.489	–	–	18.	Hager.
$FeSO_4 + 7H_2O$	1.025	1.053	1.081	1.111	1.141	1.173	1.238	–	–	17.2	Schiff.
$MgSO_4$	1.051	1.104	1.161	1.221	1.284	–	–	–	–	15	Gerlach.
$MgSO + 7H_2O$	1.025	1.050	1.075	1.101	1.129	1.155	1.215	1.278	–	15.	“
$Na_2So_4 + 10H_2O$	1.019	1.039	1.059	1.081	1.102	1.124	–	–	–	15.	“
$CuSO_4 + 5H_2O$	1.031	1.064	1.098	1.134	1.173	1.213	–	–	–	18.	Schiff.
$MnSO_4 + 4H_2O$	1.031	1.064	1.099	1.135	1.174	1.214	1.303	1.398	–	15.	Gerlach.
$ZnSO_4 + 7H_2O$	1.027	1.057	1.089	1.122	1.156	1.191	1.269	1.351	1.443	20.5	Schiff.
$Fe_2(SO)_3+K_2SO_4 +24H_2O$	1.026	1.045	1.066	1.088	1.112	1.141	–	–	–	17.5	Franz.
$Cr_2(SO)_3+K_2SO_4 + 24H_2O$	1.016	1.033	1.051	1.073	1.099	1.126	1.188	1.287	1.454	17.5	“
$MgSO_4 + K_2SO_4 + 6H_2O$	1.032	1.066	1.101	1.138	–	–	–	–	–	15.	Schiff.
$(NH_4)_2SO_4 + FeSO_4 + 6H_2O$	1.028	1.058	1.090	1.122	1.154	1.191	–	–	–	19.	“
K_2CrO_4	1.039	1.082	1.127	1.174	1.225	1.279	1.397	–	–	19.5	“
$K_2Cr_2O_7$	1.035	1.071	1.108	–	–	–	–	–	–	19.5	Kremers.
$Fe(Cy)_6K_4$	1.028	1.059	1.092	1.126	–	–	–	–	–	15.	Schiff.
$Fe(Cy)_6K_3$	1.025	1.053	1.145	1.179	–	–	–	–	–	13	“
$Pb(C_2H_3O_2)_2 + 3H_2O$	1.031	1.064	1.100	1.137	1.177	1.220	1.315	1.426	–	15.	Gerlach.
$2NaOH + As_2O_5 + 24H_2O$	1.020	1.042	1.066	1.089	1.114	1.140	1.194	–	–	14.	Schiff.
	5	10	15	20	30	40	60	80	100		
SO_3	1.040	1.084	1.132	1.179	1.277	1.389	1.564	1.840	–	15.	Brineau.
SO_2	1.013	1.028	1.045	1.063	–	–	–	–	–	4.	Schiff.
N_2O_5	1.033	1.069	2.104	1.141	1.217	1.294	1.422	1.506	–	15.	Kolb.
$C_4H_6O_6$	1.021	1.047	1.070	1.096	1.150	1.207	–	–	–	15.	Gerlach.
$C_6H_8O_7$	1.018	1.038	1.058	1.079	1.123	1.170	1.273	–	–	15.	“
Cane sugar	1.019	1.039	1.060	1.082	1.129	1.178	1.289	–	–	17.5	“
HCl	1.025	1.050	1.075	1.101	1.151	1.200	–	–	–	15.	Kolb.
HBr	10.35	1.073	1.114	1.158	1.257	1.376	–	–	–	14.	Topsöe.
HI	1.037	1.077	1.118	1.165	1.271	1.400	–	–	–	13.	“
H_2SO_4	1.032	1.069	1.106	1.145	1.223	1.307	1.501	1.732	1.838	15.	Kolb.
H_2SiFl_6	1.040	1.082	1.127	1.174	1.273	–	–	–	–	17.5	Stolba.
P_2O_5	1.035	1.077	1.119	1.167	1.271	1.385	1.676	–	–	17.5	Hager.
$P_2O_5 + 3H_2O$	1.027	1.057	1.086	1.119	1.188	1.264	1.438	–	–	15.	Schiff.
HNO	1.028	1.056	1.088	1.119	1.184	1.250	1.373	1.459	1.528	15.	Kolb.
$C_2H_4O_2$	1.007	1.014	1.021	1.028	1.041	1.052	1.068	1.075	1.055	15.	Oudemans.

Table 102.

DENSITY OF WATER AT DIFFERENT TEMPERATURES BETWEEN 0° AND 32° C.*

The following table gives the relative density of water containing air in solution, — the maximum density of water free from air being taken as unity. The correction required to reduce to densities of water free from air are given at the foot of the table. For all ordinary purposes the correction may be neglected. The temperatures are for the hydrogen thermometer.

Temp. C.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
−0	0.9998742	8678	8613	8547	8478	8408	8336	8263	8188	8111
+0	0.9998742	8804	8864	8922	8979	9035	9088	9140	9191	9240
1	9287	9332	9376	9419	9460	9499	9536	9572	9607	9640
2	9671	9701	9729	9755	9780	9803	9825	9846	9864	9881
3	9897	9911	9923	9934	9944	9952	9958	9963	9966	9968
4	9968	9966	9964	9959	9953	9946	9933	9927	9915	9901
5	0.9999886	9870	9852	9833	9812	9790	9766	9740	9714	9685
6	9656	9625	9592	9558	9522	9485	9446	9407	9365	9322
7	9278	9232	9185	9137	9087	9035	8982	8928	8873	8815
8	8758	8697	8636	8573	8509	8443	8376	8308	8238	8167
9	8095	8021	7946	7869	7791	7712	7631	7549	7466	7381
10	0.9997295	7208	7119	7029	6937	6844	6750	6654	6558	6459
11	6360	6259	6157	6053	5949	5842	5735	5626	5516	5405
12	5292	5178	5063	4947	4829	4710	4590	4468	4345	4221
13	4096	3969	3841	3712	3581	3450	3317	3182	3047	2910
14	2772	2633	2493	2351	2208	2064	1919	1772	1624	1475
15	0.9991325	1174	1021	0867	0712	0556	0399	0240	0080	9919
16	89757	7594	9429	9264	9097	8929	8760	8589	8418	8245
17	8071	7896	7720	7543	7365	7185	7004	6823	6640	6456
18	6270	6084	5897	5708	5518	5328	5136	4943	4749	4553
19	4357	4160	3961	3762	3561	3359	3157	2953	2748	2542
20	0.9982335	2126	1917	1707	1496	1283	1070	0855	0640	0423
21	0205	9987	9767	9546	9325	9102	8878	8653	8427	8200
22	77972	7744	7514	7283	7051	6818	6584	6340	6114	5877
23	5639	5400	5160	4920	4678	4435	4191	3947	3701	3455
24	3207	2959	2709	2459	2208	1956	1702	1448	1193	0937
25	0.9970681	0423	0164	9904	9644	9382	9120	8857	8592	8327
26	68061	7794	7527	7258	6988	6718	6447	6175	5901	5628
27	5353	5077	4801	4523	4245	3966	3686	3405	3124	2841
28	2558	2274	1989	1703	1416	1129	0840	0551	0261	9971
29	59679	9387	9094	8800	8505	8209	8913	7616	7318	7019
30	0.9956720	6419	6118	5816	5514	5210	4906	4601	4296	3989
31	3682	3374	3066	2756	2446	2135	1823	1511	1198	0884

If we put D'_t for the density of water containing air and D_t for the density of water free from air, we get the following corrections on the above table to reduce to pure water: —

t =	0	1	2	3	4	5	6	7	8	9	10
$10^7(D_t - D'_t)$ =	25	27	29	31	32	33	33	34	34	33	32

t =	11	12	13	14	15	16	17	18	19	20 — 32
$10^7(D_t - D'_t)$ =	31	29	27	25	22	19	16	12	8	4 negligible.

* This table is given by Marek in "Wied. Ann.," vol. 44, p. 172, 1891.

VOLUME IN CUBIC CENTIMETRES AT VARIOUS TEMPERATURES OF A CUBIC CENTIMETRE OF WATER AT THE TEMPERATURE OF MAXIMUM DENSITY.*

The water in this case is supposed to be free from air. The temperatures are by the hydrogen thermometer.

Temp. C.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0°	1.000127	120	114	108	102	096	091	086	080	075
1	070	066	061	057	052	048	044	040	037	033
2	030	027	024	021	019	017	014	012	010	009
3	007	006	004	003	002	002	001	001	000	000
4	000	000	001	001	001	002	003	004	005	007
5	1.000008	010	012	014	016	018	020	023	026	029
6	032	035	038	041	045	049	053	057	061	065
7	069	074	079	084	089	094	099	105	110	116
8	122	128	134	141	147	154	160	167	174	181
9	189	196	204	211	219	227	235	244	252	260
10	1.000269	278	287	296	305	314	324	334	343	353
11	363	373	383	394	405	415	426	437	448	459
12	471	482	494	505	517	529	541	553	566	578
13	591	603	616	629	642	655	668	681	695	709
14	722	736	750	765	779	794	809	823	838	853
15	1.000868	884	899	914	930	945	961	977	993	$\overline{009}$
16	1025	042	058	075	091	108	125	142	159	177
17	194	211	229	247	265	283	301	319	338	356
18	374	393	412	431	450	469	488	507	527	546
19	566	585	605	625	645	666	686	707	727	748
20	1.001768	789	810	831	852	874	895	916	938	960
21	981	$\overline{003}$	$\overline{025}$	$\overline{047}$	$\overline{069}$	$\overline{092}$	$\overline{114}$	$\overline{137}$	$\overline{159}$	$\overline{182}$
22	2205	228	251	274	297	320	343	367	391	414
23	438	462	486	510	534	559	583	607	632	657
24	682	707	732	757	782	807	833	858	884	910
25	1.002935	961	987	$\overline{014}$	$\overline{040}$	$\overline{066}$	$\overline{092}$	$\overline{119}$	$\overline{146}$	$\overline{172}$
26	3199	226	253	280	307	335	362	389	417	445
27	472	500	528	556	584	612	641	669	697	726
28	754	783	812	841	870	899	928	957	987	$\overline{016}$
29	4045	075	105	134	164	194	224	254	284	315
30	1.004345	375	406	436	467	498	529	560	591	622
31	653	684	716	748	780	811	843	875	907	939
32	971	$\overline{003}$	$\overline{036}$	$\overline{068}$	$\overline{101}$	$\overline{133}$	$\overline{166}$	$\overline{199}$	$\overline{231}$	$\overline{264}$
33	5297	330	363	396	430	463	497	530	564	597
34	631	665	699	733	767	801	835	870	904	939
35	1.005973	$\overline{008}$	$\overline{042}$	$\overline{077}$	$\overline{111}$	$\overline{146}$	$\overline{181}$	$\overline{217}$	$\overline{252}$	$\overline{287}$

* The table is quoted from Landolt and Börnstein's "Physikalische Chemie Tabellen," and depends on experiments by Thiesen, Scheel, and Marek.

DENSITY AND VOLUME OF WATER.*

The mass of one cubic centimetre at 4° C. is taken as unity.

Temp. C.	Density.	Volume.	Temp. C.	Density.	Volume.
−10°	0.998145	1.001858	25°	0.99712	1.00289
−9	8427	1575	26	687	314
−8	8685	1317	27	660	341
−7	8911	1089	28	633	368
−6	9118	0883	29	605	396
−5	0.999298	1.000702	30	0.99577	1.00425
−4	9455	0545	31	547	455
−3	9590	0410	32	517	486
−2	9703	0297	33	485	518
−1	9797	0203	34	452	551
0	0.999871	1.000129	35	0.99418	1.00586
1	9928	0072	36	383	621
2	9969	0031	37	347	657
3	9991	0009	38	310	694
4	1.000000	0000	39	273	732
5	0.999990	1.000010	40	0.99235	1.00770
6	9970	0030	41	197	809
7	9933	0067	42	158	849
8	9886	0114	43	118	889
9	9824	0176	44	078	929
10	0.999747	1.000253	45	0.99037	1.00971
11	9655	0345	46	8996	1014
12	9549	0451	47	954	1057
13	9430	0570	48	910	1101
14	9299	0701	49	865	1148
15	0.999160	1.000841	50	0.98820	1.01195
16	9002	0999	55	582	439
17	8841	1160	60	338	691
18	8654	1348	65	074	964
19	8460	1542	70	7794	256
20	0.998259	1.001744	75	0.97498	1.01566
21	8047	1957	80	194	887
22	7826	2177	85	6879	221
23	7601	2405	90	556	567
24	7367	2641	95	219	931
25	0.997120	1.002888	100	0.95865	1.02312

* Rossetti, "Berl. Ber." 1867.

DENSITY OF MERCURY.

Density or mass in grammes per cubic centimetre, and the volume in cubic centimetres of one gramme of mercury. The density at 0° is taken as 13.5956,* and the volume at temperature t is $V_t = V_0(1 + .000181792t + 175 \times 10^{-12}t^2 + 35116 \times 10^{-16}t^3)$.†

Temp. C.	Mass in grammes per cub. cm.	Volume of 1 gramme in cub. cms.	Temp. C.	Mass in grammes per cub. cm.	Volume of 1 gramme in cub. cms.
−10°	13.6203	0.0734195	**30°**	13.5218	0.0739544
−9	6178	4329	31	5194	9678
−8	6153	4463	32	5169	9812
−7	6129	4596	33	5145	9945
−6	6104	4730	34	5120	40079
−5	13.6079	0.0734864	**35**	13.5096	0.0740213
−4	6055	4997	36	5071	0346
−3	6030	5131	37	5047	0480
−2	6005	5265	38	5022	0614
−1	5981	5398	39	4998	0748
0	13.5956	0.0735532	**40**	13.4974	0.0740882
1	5931	5666	50	4731	2221
2	5907	5800	60	4488	3561
3	5882	5933	70	4246	4901
4	5857	6067	80	4005	6243
5	13.5833	0.0736201	**90**	13.3764	0.0747586
6	5808	6334	100	3524	8931
7	5783	6468	110	3284	50276
8	5759	6602	120	3045	1624
9	5734	6736	130	2807	2974
10	13.5709	0.0736869	**140**	13.2569	0.0754325
11	5685	7003	150	2331	5679
12	5660	7137	160	2094	7035
13	5635	7270	170	1858	8394
14	5611	7404	180	1621	9755
15	13.5586	0.0737538	**190**	13.1385	0.0761120
16	5562	7672	200	1150	2486
17	5537	7805	210	0915	3854
18	5513	7939	220	0680	5230
19	5488	8073	230	0445	6607
20	13.5463	0.0738207	**240**	13.0210	0.0767988
21	5439	8340	250	12.9976	9372
22	5414	8474	260	9742	70760
23	5390	8608	270	9508	1252
24	5365	8742	280	9274	3549
25	13.5341	0.0738875	**290**	12.9041	0.0774950
26	5316	9009	300	8807	6355
27	5292	9143	310	8573	7765
28	5267	9277	320	8340	9180
29	5243	9411	330	8107	80600
30	13.5218	0.0739544	**340**	12.7873	0.0782025
			350	7640	3455
			360	7406	4891

* Marek, "Trav. et Mém. du Bur. Int. des Poids et Més." 2, 1883.
† Broch, l. c.

SPECIFIC GRAVITY OF AQUEOUS ETHYL ALCOHOL.

(a) The numbers here tabulated are the specific gravities at 60° F., in terms of water at the same temperature, of water containing the percentages by weight of alcohol of specific gravity .7938, with reference to the same temperatures.*

Percentage of alcohol by weight.	0	1	2	3	4	5	6	7	8	9
	Specific gravity at 15°.56 C. in terms of water at the same temperature.									
0	1.0000	.9981	.9965	.9947	.9930	.9914	.9898	.9884	.9869	.9855
10	.9841	.9828	.9815	.9802	.9789	.9778	.9766	.9753	.9741	.9728
20	.9716	.9703	.9691	.9678	.9665	.9652	.9638	.9623	.9609	.9593
30	.9578	.9560	.9544	.9528	.9511	.9490	.9470	.9452	.9434	.9416
40	.9396	.9376	.9356	.9335	.9314	.9292	.9270	.9249	.9228	.9206
50	0.9184	.9160	.9135	.9113	.9090	.9069	.9047	.9025	.9001	.8979
60	.8956	.8932	.8908	.8886	.8863	.8840	.8816	.8793	.8769	.8745
70	.8721	.8696	.8672	.8649	.8625	.8603	.8581	.8557	.8533	.8508
80	.8483	.8459	.8434	.8408	.8382	.8357	.8331	.8305	.8279	.8254
90	.8228	.8199	.8172	.8145	.8118	.8089	.8061	.8031	.8001	.7969

(b) The following are the values adopted by the "Kaiserlichen Normal-Aichungs Kommission." They are based on Mendelejeff's formula,† and are for alcohol of specific gravity .79425, at 15° C., in terms of water at 15° C.; temperatures measured by the hydrogen thermometer.

Percentage of alcohol by weight.	0	1	2	3	4	5	6	7	8	9
	Specific gravity at 15° C. in terms of water at the same temperature.									
0	1.00000	.99812	.99630	.99454	.99284	.99120	.98963	.98812	.98667	.98528
10	.98393	.98262	.98135	.98010	.97888	.97768	.97648	.97528	.97408	.97287
20	.97164	.97040	.96913	.96783	.96650	.96513	.96373	.96228	.96080	.95927
30	.95770	.95608	.95443	.95273	.95099	.94920	.94738	.94552	.94363	.94169
40	.93973	.93773	.93570	.93365	.93157	.92947	.92734	.92519	.92303	.92088
50	0.91865	.91644	.91421	.91197	.90972	.90746	.90519	.90292	.90063	.89834
60	89604	.89373	.89141	.88909	.88676	.88443	.88208	.87974	.87738	.87502
70	87265	.87028	.86789	.86550	.86310	.86070	.85828	.85586	.85342	.85098
80	84852	.84606	.84358	.84108	.83857	.83604	.83349	.83091	.82832	.82569
90	82304	.82036	.81763	.81488	.81207	.80923	.80634	.80339	.80040	.79735

(c) The following values have the same authority as the last; the percentage of alcohol being given by volume instead of by weight, and the temperature 15°.56 C. on the mercury in Thuringian glass thermometer; the specific gravity of the absolute alcohol being .79391.

Percentage of alcohol by volume.	0	1	2	3	4	5	6	7	8	9
	Specific gravity at 15°.56 C. in terms of water at same temperature.									
0	1.00000	.99847	.99699	.99555	.99415	.99279	.99147	.90019	.98895	.98774
10	.98657	.98543	.98432	.98324	.98218	.98114	.98011	.97909	.97808	.97708
20	.97608	.97507	.97406	.97304	.97201	97097	.96991	.96883	.96772	.96658
30	.96541	.96421	.96298	.96172	.96043	.95910	.95773	.95632	.95487	.95338
40	.95185	.95029	.94863	.94704	.94536	.94364	.94188	.94008	.93824	.93636
50	0.93445	.93250	.93052	.92850	.92646	.92439	.92229	.92015	.91799	.91580
60	.91358	.91134	.90907	.90678	.90447	.90214	.89978	.89740	.89499	.89256
70	.89010	.88762	.88511	.88257	.88000	.87740	.87477	.87211	.86943	.86670
80	.86395	.86116	.85833	.85547	.85256	.84961	.84660	.84355	.84044	.83726
90	.83400	.83065	.82721	.82365	.81997	.81616	.81217	.80800	.80359	.79891

* Fownes, "Phil. Trans. Roy. Soc." 1847.
† "Pogg. Ann." vol. 138, 1869.

DENSITY OF AQUEOUS METHYL ALCOHOL.*

Densities of aqueous methyl alcohol at 0° and 15.56 C., water at 4° C. being taken as 100000. The numbers in tl columns *a* and *b* are the coefficients in the equation $\rho_t = \rho_0 - at - bt^2$ where ρ_t is the density at temperature This equation may be taken to hold between 0° and 20° C.

Percentage of CH_4O.	Density at 0° C.	Density at 15°.56 C.	*a*	*b*
0	99987	99907	−6.0	0.705
1	99806	99729	−5.4	.694
2	99631	99554	−4.8	.681
3	99462	99382	−3.9	.670
4	99299	99214	−3.0	.659
5	99142	99048	−2.2	0.648
6	98990	98893	−1.2	.634
7	98843	98726	−0.2	.621
8	98701	98569	+0.9	.609
9	98563	98414	2.1	.596
10	98429	98262	3.3	0.581
11	98299	98111	4.8	.569
12	98171	97962	6.2	.552
13	98048	97814	7.8	.536
14	97926	97668	9.5	.519
15	97806	97523	11.0	0.500
16	97689	97379	12.5	.480
17	97573	97235	14.5	.461
18	97459	97093	16.2	.440
19	97346	96950	18.3	.420
20	97233	96808	20.0	0.398
21	97120	96666	22.2	.373
22	97007	96524	24.3	.350
23	96894	96381	26.4	.321
24	96780	96238	29.0	.291
25	96665	96093	31.3	0.261
26	96549	95949	33.8	.230
27	96430	95802	36.0	.191
28	96310	95655	38.8	.151
29	96187	95506	41.1	.106
Equation $\rho_t = \rho_0 - at$				
30	96057	95367	44.36	Term bt^2 negligible.
31	95921	95211	45.66	
32	95783	95053	46.93	
33	95643	94894	48.17	
34	95500	94732	49.39	
35	95354	94567	50.58	
36	95204	94399	51.75	
37	95051	94228	52.89	
38	94895	94055	54.01	
39	94734	93877	55.10	
40	94571	93697	56.16	
41	94400	93510	57.20	
42	94239	93335	58.22	
43	94076	93155	59.20	
44	93911	92975	60.17	
45	93744	92793	61.10	
46	93575	92610	62.01	
47	93403	92424	62.90	
48	93229	92237	63.76	
49	93052	92047	64.60	

Percentage of CH_4O.	Density at 0° C.	Density at 15°.56 C.	*a*
50	92873	91855	65.41
51	92691	91661	66.19
52	92507	91465	66.95
53	92320	91267	67.68
54	92130	91066	68.39
55	91938	90863	69.07
56	91742	90657	69.72
57	91544	90450	70.35
58	91343	90239	70.96
59	91139	90026	71.54
60	90917	89798	71.96
61	90706	89580	72.37
62	90492	89358	72.91
63	90276	89133	73.45
64	90056	88905	73.98
65	89835	88676	74.51
66	89611	88443	75.05
67	89384	88208	75.57
68	89154	87970	76.10
69	88922	87714	76.62
70	88687	87487	77.14
71	88470	87262	77.66
72	88237	87021	78.18
73	88003	86779	78.69
74	87767	86535	79.20
75	87530	86290	79.71
76	87290	86042	80.22
77	87049	85793	80.72
78	86806	85542	81.23
79	86561	85290	81.73
80	86314	85035	82.22
81	86066	84779	82.72
82	85816	84521	83.21
83	85564	84262	83.70
84	85310	84001	84.19
85	85055	83738	84.67
86	84798	83473	85.16
87	84539	83207	85.64
88	84278	82938	86.12
89	84015	82668	86.59
90	83751	82396	87.07
91	83485	82123	87.54
92	83218	81849	88.01
93	82948	81572	88.48
94	82677	81293	88.94
95	82404	81013	89.40
96	82129	80731	89.86
97	81853	80448	90.32
98	81576	80164	90.78
99	81295	79872	91.23
100	81015	79589	91.68

* Quoted from the results of Dittmar & Fawsitt, "Trans. Roy. Soc. Edin." vol. 33.

VARIATION OF THE DENSITY OF ALCOHOL WITH TEMPERATURE.

(a) The density of alcohol at t° in terms of water at 4° is given* by the following equation:

$$d_t = 0.80025 - 0.0008340t - 00000029t^2.$$

From this formula the following table has been calculated.

Temp. C.	Density or Mass in grammes per cubic centimetre.									
	0	1	2	3	4	5	6	7	8	9
0	.80625	.80541	.80457	.80374	.80290	.80207	.80123	.80039	.79956	.79872
10	.79788	.79704	.79620	.79535	.79451	.79367	.79283	.79198	.79114	.79029
20	.78945	.78860	.78775	.78691	.78606	.78522	.78437	.78352	.78267	.78182
30	.78097	.78012	.77927	.77841	.77756	.77671	.77585	.77500	.77414	.77329

(b) Variations with temperature of the density of water containing different percentages of alcohol. Water at 4° C. is taken as unity.†

Percentage of alcohol by weight.	Density at temp. C.				Percentage of alcohol by weight.	Density at temp. C.			
	0°	10°	20°	30°		0°	10°	20°	30°
0	0.99988	0.99975	0.99831	0.99579	**50**	0.92940	0.92182	0.91400	0.90577
5	.99135	.99113	.98945	.98680	55	.91848	.91074	.90275	.89456
10	.98493	.98409	.98195	.97892	60	.90742	.89944	.89129	.88304
15	.97995	.97816	.97527	.97142	65	.89595	.88790	.97961	.87125
20	.97566	.97263	.96877	.96413	70	.88420	.87613	.86781	.85925
25	0.97115	0.96672	0.96185	0.95628	**75**	0.87245	0.86427	0.85580	0.84719
30	.96540	.95998	.95403	.94751	80	.86035	.85215	.84366	.83483
35	.95784	.95174	.94514	.93813	85	.84789	.83967	.83115	.82232
40	.94939	.94255	.93511	.92787	90	.83482	.82665	.81801	.80918
45	.93977	.93254	.92493	.91710	95	.82119	.81291	.80433	.79553
50	0.92940	0.92182	0.91400	0.90577	**100**	0.80625	0.79788	0.78945	0.78096

* Mendelejeff, "Pogg. Ann." vol. 138.
† Quoted from Landolt and Börnstein, "Phys. Chem. Tab." p. 223.

VELOCITY OF SOUND IN AIR.

Rowland has discussed (Proc. Am. Acad. vol. 15, p. 144) the principal determination of the velocity of sound in atmospheric air. The following table, together with the footnotes and references, are quoted from his paper. Some later determinations will be found in Table 111, on the velocity of sound in gases.

Observer. (See References below.)	Date.	Place of determination.	Number of observations made.	Temperature observed.	Velocity observed.	Velocity reduced to 0° C. and ordinary air.	Velocity reduced to 0° and dry air.	Velocity approximately reduced to 0° C. and dry air (mean).[a]	Estimated weight of observation.
1	1738	France . .	-	5°–7°.5 C.	172.56 T.	332.9m.	-	332.6m.	2
2	1811	Düsseldorf	40	—	-	333.7[b]	-	332.7	2
3	1821	India . .	120	83°.95 F.	1149.2 ft.	333.0[c]	-	330.9	2
			70	79°.9 F.	1131.5 ft.	329.6[c]	-		
4	1822	France . .	30	15°.9 C.	340.89 m.	331.36	-	330.8	4
5	1822	Austria . .	88	9°.4 C.	-	332.96	-	332.5	3
6	1823	Holland	22 shots	11°.6 C.	340.37	333.62	332.82[d]	-	7
			14 "	11°.0 C.[e]	339.27	332.62	331.91[d]	-	
7	1824–5	Port Bowen	51	−38° F. to +33° F.	-	332.27[f]	-	332.0	1
8	1839	—	-	5°.5 to 9° C.	336.50	332.20[g]	-	331.8	1
9	1844	Alps . . .	34	8°.17 C.	338.01	332.11	332.37	-	4
10	1868*	France . .	149	2° to 20° C.	-	-	330.71	-	10

General mean deduced by Rowland, 331.75.

Correcting for the normal carbonic acid in the atmosphere, this becomes 331.78 metres per second in pure dry air at 0° C.

REFERENCES.

1 French Academy: "Mém. de l'Acad. des Sci." 1738, p. 128.
2 Benzenburg: Gibberts's "Annalen," vol. 42, p. 1.
3 Goldingham: "Phil. Trans." 1823, p. 96.
4 Bureau of Longitude: "Ann. de Chim." 1822, vol. 20, p. 210; also, "Œuvres d'Arago," "Mem. Sci." ii. 1.
5 Stampfer und Von Myrbach: "Pogg. Ann." vol. 5, p. 496.
6 Moll and Van Beek: "Phil. Trans." 1824, p. 424.
7 Parry and Foster: "Journal of the Third Voyage," 1824–5, App. p. 86; "Phil. Trans." 1828, p. 97.
8 Savant: "Ann. de Chim." sér. 2, vol. 71, p. 20. Recalculated.
9 Bravais and Martins: "Ann. de Chim." sér. 3, vol. 13, p. 5.
10 Regnault: "Rel. des Exp." iii. p. 533.

a I believe that I calculated these reduced numbers on the supposition that the air was rather more than half saturated with moisture.
b Reduced to 0° C. by empirical formula.
c Wind calm.
d Moll and Van Beek found 332.049 at 0° C. for dry air. They used the coefficient .00375 to reduce. I take the numbers as recalculated by Schröder van der Kolk.
e An error of 0.21° C. was made in the original. See Schröder van der Kolk, "Phil. Mag." 1865.
f Corrected for wind by Galbraith.
g Recalculated from Savart's results.

* This is given as 1864 in Rowland's table. The original paper is in "Mém. de l'Institut," vol. 37, 1868.

TABLE 110.

VELOCITY OF SOUND IN SOLIDS.

The numbers given in this table refer to the velocity of sound along a bar of the substance, and hence depend on the Young's Modulus of elasticity of the material. The elastic constants of most of the materials given in this table vary through a somewhat wide range, and hence the numbers can only be taken as rough approximations to the velocity which may be obtained in any particular case. When temperatures are not marked, between 10° and 20° is to be understood.

Substance.	Temp. C. °	Velocity in metres per second.	Velocity in feet per second.	Authority.
Metals: Aluminium	–	5104	16740	Masson.
Brass	–	3500	11480	Various.
Cadmium	–	2307	7570	Masson.
Cobalt	–	4724	15500	"
Copper	20	3560	11670	Wertheim.
"	100	3290	10800	"
"	200	2950	9690	"
Gold (soft)	20	1743	5717	"
"	100	1720	5640	"
"	200	1735	5691	"
Gold (hard)	–	2100	6890	Various.
Iron and soft steel	–	5000	16410	"
Iron	20	5130	16820	Wertheim.
"	100	5300	17390	"
"	200	4720	15480	"
" cast steel	20	4990	16360	"
" " "	100	4920	16150	"
" " "	200	4790	15710	"
Magnesium	–	4602	15100	Melde.
Nickel	–	4973	16320	Masson.
Palladium	–	3150	10340	Various.
Platinum	20	2690	8815	Wertheim.
"	100	2570	8437	"
"	200	2460	8079	"
Silver	20	2610	8553	"
"	100	2640	8658	"
"	200	2480	8127	"
Tin	–	2500	8200	Various.
Zinc	–	3700	12140	"
Various: Brick	–	3652	11980	Chladni.
Clay rock	–	3480	11420	Gray & Milne.
Granite	–	3950	12960	"
Marble	–	3810	12500	"
Slate	–	4510	14800	"
Tuff	–	2850	9350	"
Glass { from	–	5000	16410	Various.
Glass { to	–	6000	19690	"
Ivory	–	3013	9886	Ciccone & Campanile.
Vulcanized rubber (black)	0	54	177	Exner.
" " (black)	50	31	102	"
" " (red)	0	69	226	"
" " "	70	34	111	"
Woods: Ash, along the fibre	–	4670	15310	Wertheim.
" across the rings	–	1390	4570	"
" along the rings	–	1260	4140	"
Beech, along the fibre	–	3340	10960	"
" across the rings	–	1840	6030	"
" along the rings	–	1415	4640	"
Elm, along the fibre	–	4120	13516	"
" across the rings	–	1420	4665	"
" along the rings	–	1013	3324	"
Fir, along the fibre	–	4640	15220	"
Maple "	–	4110	13470	"
Oak "	–	3850	12620	"
Pine "	–	3320	10900	"
Poplar "	–	4280	14050	"
Sycamore "	–	4460	14640	"

VELOCITY OF SOUND IN LIQUIDS AND GASES.

Substance.	Temp. C. °	Velocity in metres per second.	Velocity in feet per second.	Authority.
Liquids: Alcohol	8.4	1264	4148	Martini.
"	23	1160	3806	Wertheim.
Ether	0	1159	3803	"
Oil of turpentine	24	1212	3977	"
Water (Lake Geneva)	9	1435	4708	Colladon & Sturm.
" (from Seine river)	15	1437	4714	Wertheim.
" " " "	30	1528	5013	"
" " " "	60	1724	5657	"
Water	3.9	1399	4591	Martini.
"	13.7	1437	4714	"
"	25.2	1457	4780	"
Gases: Air	0	333	1092	Dulong.
"	0	331.6	1087	Wertheim.
"	0	333	1092	Masson.
"	0	330.7	1085	Le Roux.
"	0	332.1	1089	Schneebeli.
"	0	332.5	1091	Kayser.
"	0	331.9	1089	Wullner.
"	0	331.7	1088	Blaikley.
"	0	331.2	1086	Violle & Vautier.
"	—10.9	326.1	1070	Greely.
"	—25.7	317.1	1040	"
"	—37.8	309.7	1016	"
"	—45.6	305.6	1002	"
"	0	332.4	1091	Stone.
Ammonia	0	415	1361	Masson.
Carbon monoxide	0	337.1	1106	Wullner.
" "	0	337.4	1107	Dulong.
" dioxide	0	261.6	858	"
Carbon disulphide	0	189	606	Masson.
Chlorine	0	206.4	677	Martini.
"	0	205.3	674	Strecker.
Ethylene	0	314	1030	Dulong.
Hydrogen	0	1269.5	4165	"
"	0	1286.4	4221	Zoch.
Illuminating gas	0	490.4	1609	"
Methane	0	422	1385	Masson.
Nitric oxide	0	325	1066	"
Nitrous oxide	0	261.8	859	Dulong.
Oxygen	0	317.2	1041	"
Vapors: Alcohol	0	230.6	756	Masson.
Ether	0	179.2	588	"
Water	0	401	1315	"
"	96	410	1345	"

TABLE 112.

FORCE OF GRAVITY FOR SEA LEVEL AND DIFFERENT LATITUDES.

This table has been calculated from the formula $g_\phi = g_{45}\,[1 - .002662 \cos 2\phi]$,* where ϕ is the latitude.

Latitude ϕ.	g in cms. per sec. per sec.	Log.	g in inches per sec. per sec.	Log.	g in feet per sec. per sec.	Log.
0°	977.989	2.990334	385.034	2.585498	32.0862	1.506318
5	8.029	0352	.050	5517	.0875	6336
10	.147	0404	.096	5570	.0916	6388
15	.339	0490	.173	5655	.0977	6474
20	.600	0605	.275	5771	.1062	6590
25	978.922	2.990748	385.403	2.585914	32.1168	1.506732
30	9.295	0913	.548	6079	.1290	6898
31	.374	0949	.580	6114	.1316	6933
32	.456	0985	.612	6150	.1343	6969
33	.538	1021	.644	6187	.1370	7005
34	979.622	2.991059	385.677	2.586224	32.1398	1.507043
35	.707	1096	.711	6262	.1425	7080
36	.793	1135	.745	6300	.1454	7119
37	.880	1173	.779	6339	.1490	7167
38	.968	1212	.813	6377	.1511	7196
39	980.057	2.991251	385.849	2.586417	32.1540	1.507236
40	.147	1291	.884	6457	.1570	7275
41	.237	1331	.919	6496	.1607	7325
42	.327	1372	.955	6537	.1630	7356
43	.418	1411	.990	6577	.1659	7395
44	980.509	2.991452	386.026	2.586617	32.1688	1.507436
45	.600	1492	.062	6657	.1719	7476
46	.691	1532	.098	6698	.1748	7516
47	.782	1573	.134	6738	.1778	7557
48	.873	1613	.170	6778	.1808	7597
49	980.963	2.991653	386.205	2.586818	32.1838	1.507637
50	1.053	1693	.241	6858	.1867	7677
51	.143	1732	.276	6898	.1896	7716
52	.231	1772	.311	6937	.1924	7756
53	.318	1810	.345	6975	.1954	7794
54	981.407	2.991849	386.380	2.587014	32.1983	1.507833
55	.493	1887	.414	7053	.2011	7871
56	.578	1925	.447	7090	.2039	7909
57	.662	1962	.480	7127	.2067	7946
58	.744	1998	.513	7164	.2094	7983
59	981.825	2.992034	386.545	2.587200	32.2121	1.508018
60	.905	2070	.576	7235	.2147	8054
65	2.278	2234	.723	7400	.2276	8229
70	.600	2377	.849	7542	.2375	8361
75	.861	2492	.952	7657	.2460	8476
80	983.053	2.992577	387.028	2.587742	32.2523	1.508561
85	.171	2620	.074	7794	.2562	8613
90	.210	2646	.090	7812	.2575	8631

* The constant .002662 is based on data given by Harkness (Solar Parallax and Related Constants, Washington, 1891).

The force of gravity for any latitude ϕ and elevation above sea level h is very nearly expressed by the equation

$$g_\phi = g_{45}\,(1 - .002662 \cos 2\phi)\left[1 - \frac{2h}{R}\left(1 - \frac{3\delta}{4\Delta}\right)\right],$$

where R is the earth's radius, δ the density of the surface strata, and Δ the mean density of the earth. When $\delta = 0$ we get the formula for elevation in air. For ordinary elevations on land $\frac{\delta}{\Delta}$ is nearly $\frac{1}{2}$, which gives for the correction at latitude 45° for elevated portions of the earth's surface

$$g_{45}\cdot\frac{5h}{4R} = 980.6 \times \frac{5h}{4R} = 1225.75\,\frac{h}{R} \text{ in dynes.}$$

$$= 386.062 \times \frac{5h}{4R} = 482.562\,\frac{h}{R} \text{ in inch pound units.}$$

$$= 32.1719 \times \frac{5h}{4R} = 40.2149\,\frac{h}{R} \text{ in poundals.}$$

This gives per 100 feet elevation a correction of

.00588 dynes
.00232 inch pound units } diminution.
[illegible] poundals

GRAVITY.

In this table the results of a number of the more recent gravity determinations are brought together. They serve to show the degree of accuracy which may be assumed for the numbers in Table 112. In general, gravity is a little lower than the calculated value for stations far inland and slightly higher on the coast line.

Place.	Latitude. N. +, S. —.	Elevation in metres.	Gravity in dynes. Observed.	Gravity in dynes. Reduced to sea level.	Reference.
Singapore	1° 17′	14	978.07	978.07	1
Georgetown, Ascension	—7 56	5	978.24	978.24	2
Green Mountain, Ascension	—7 57	686	978.08	978.21	2
Loanda, Angola	—8 49	46	978.14	978.15	2
Caroline Islands	—10 00	2	978.36	978.36	3
Bridgetown, Barbadoes	13 04	18	978.16	978.16	2
Jamestown, St. Helena	—15 55	10	978.66	978.66	2
Longwood, "	—15 57	533	978.52	978.58	2
Pakaoao, Sandwich Islands	20 43	3001	978.27	978.84	3
Lahaina, " "	20 52	3	978.85	978.85	3
Haiki, " "	20 56	117	978.90	978.92	3
Honolulu, " "	21 18	3	978.96	978.96	3
St. Georges, Bermuda	32 23	2	979.75	979.75	2
Sidney, Australia	—33 52	43	979.67	979.68	1
Cape Town	—33 56	11	979.61	979.61	2
Tokio, Japan	35 41	6	979.94	979.94	1
Auckland, New Zealand	—36 52	43	979.67	979.68	1
Mount Hamilton, Cal. (Lick Obs.)	37 20	1282	979.64	979.89	4
" " " "	37 20	1282	979.68	979.92	5
San Francisco, Cal.	37 47	114	979.95	979.97	4
" " "	37 47	114	980.02	980.04	5
Washington, D. C.*	38 53	10	980.10	980.10	4
Denver, Colo.	39 54	1645	979.68	979.98	5
York, Pa.	39 58	122	980.12	980.14	6
Ebensburgh, Pa.	40 27	651	980.08	980.20	6
Allegheny, Pa.	40 28	348	980.09	980.15	6
Hoboken, N. J.	40 44	11	980.26	980.26	4
Salt Lake City, Utah	40 46	1288	979.82	980.05	5
Chicago, Ill.	41 49	165	980.34	980.37	5
Pampaluna, Spain	42 49	450	980.34	980.42	7
Montreal, Canada	45 31	100	980.73	980.75	5
Geneva, Switzerland	46 12	405	980.58	980.64	8
" "	46 12	405	980.60	980.66	9
Berne, "	46 57	572	980.61	980.69	9
Zurich, "	47 23	466	980.67	980.74	9
Paris, France	48 50	67	980.96	980.97	8
Kew, England	51 28	7	981.20	981.20	8
Berlin, Germany	52 30	49	981.26	981.27	8
Port Simpson, B. C.	54 34	6	981.45	981.45	4
Burroughs Bay, Alaska	55 59	0	981.49	981.49	4
Wrangell, "	56 28	7	981.59	981.59	4
Sitka, "	57 03	8	981.68	981.68	4
St. Paul's Island, "	57 07	12	981.66	981.66	4
Juneau, "	58 18	5	981.73	981.73	4
Pyramid Harbor, "	59 10	5	981.81	981.81	4
Yakutat Bay, "	59 32	4	981.82	981.82	4

1 Smith: "United States Coast and Geodetic Survey Report for 1884," App. 14.
2 Preston: "United States Coast and Geodetic Survey Report for 1890," App. 12.
3 Preston: Ibid. 1888, App. 14.
4 Mendenhall: Ibid. 1891, App. 15.
5 Defforges: "Comptes Rendus," vol. 118, p. 231.
6 Pierce: "U. S. C. and G. S. Rep. 1883," App. 19.
7 Cebrian and Los Arcos: "Comptes Rendus des Séances de la Commission Permanente de l'Association Géodesique International," 1893.
8 Pierce: "U. S. C. and G. S. Report 1876, App. 15, and 1881, App. 17."
9 Messerschmidt: Same reference as 7.

* In all the values given under references 1–4 gravity at Washington has been taken at 980.100, and the others derived from that by comparative experiments with invariable pendulums.

TABLE 114.

SUMMARY OF RESULTS OF THE VALUE OF GRAVITY (g) AT STATIONS IN THE UNITED STATES, OCCUPIED BY THE U. S. COAST AND GEODETIC SURVEY DURING THE YEAR 1894.*

Station.	Latitude.	Longitude.	Elevation.	g observed.
	° ′ ″	° ′ ″	Metres.	Dynes.
Atlantic Coast.				
Boston, Mass.	42 21 33	71 03 50	22	980.382
Cambridge, Mass.	42 22 48	71 07 45	14	980.384
Princeton, N. J.	40 20 57	74 39 28	64	980.164
Philadelphia, Pa.	39 57 06	75 11 40	16	980.182
Washington, C. & G. S.	38 53 13	77 00 32	14	980.098
Washington, Smithsonian.	38 53 20	77 01 32	10	980.100†
Appalachian Elevation.				
Ithaca, N. Y.	42 27 04	76 29 00	247	980.286
Charlottesville, Va.	38 02 01	78 30 16	166	979.924
Deer Park, Md.	39 25 02	79 19 50	770	979.921
Central Plains.				
Cleveland, Ohio	41 30 22	81 36 38	210	980.227
Cincinnati, Ohio	39 08 20	84 25 20	245	979.990
Terre Haute, Ind.	39 28 42	87 23 49	151	980.058
Chicago, Ill.	41 47 25	87 36 03	182	980.264
St. Louis, Mo.	38 38 03	90 12 13	154	979.987
Kansas City, Mo.	39 05 50	94 35 21	278	979.976
Ellsworth, Kan.	38 43 43	98 13 32	469	979.912
Wallace, Kan.	38 54 44	101 35 26	1005	979.741
Colorado Springs, Col.	38 50 44	104 49 02	1841	979.476
Denver, Col.	39 40 36	104 56 55	1638	979.595
Rocky Mountains.				
Pike's Peak, Col.	38 50 20	105 02 02	4293	978.940
Gunnison, Col.	38 32 33	106 56 02	2340	979.328
Grand Junction, Col.	39 04 09	108 33 56	1398	979.619
Green River, Utah	38 59 23	110 09 56	1243	979.622
Grand Canyon, Wyo.	44 43 16	110 29 44	2386	979.885
Norris Geyser Basin, Wyo.	44 44 09	110 42 02	2276	979.936
Lower Geyser Basin, Wyo.	44 33 21	110 48 08	2200	979.918
Pleasant Valley, Jct., Utah	39 50 47	111 00 46	2191	979.498
Salt Lake City, Utah	40 46 04	111 53 46	1322	979.789

TABLE 115.

LENGTH OF SECONDS PENDULUM AT SEA LEVEL FOR DIFFERENT LATITUDES.‡

Latitude.	Length in centimetres.	Log.	Length in inches.	Log.	Latitude.	Length in centimetres.	Log.	Length in inches.	Log.
0	99.0910	1.996034	39.0121	1.591200	**50**	99.4014	1.997393	39.1344	1.592558
5	.0950	6052	.0137	1217	55	.4459	7587	.1520	2753
10	.1079	6104	.0184	1270	60	.4876	7770	.1683	2935
15	.1265	6190	.0261	1356	65	.5255	7935	.1832	3100
20	.1529	6306	.0365	1471	70	.5581	8077	.1960	3242
25	99.1855	1.996448	39.0493	1.591614	**75**	99.5845	1.998192	39.2065	1.593358
30	.2234	6614	.0642	1779	80	.6040	8277	.2141	.3442
35	.2651	6796	.0806	1962	85	.6160	8329	.2188	.3494
40	.3096	6991	.0982	2157	90	.6200	8347	.2204	.3512
45	.3555	7192	.1163	2357					

* G. R. Putnam, Phil. Soc. of Washington, Bull. vol. xiii
† Taken as standard. The other values were obtained from this by means of invariable pendulums.
‡ Calculated from force of gravity table by the formula $l = g/\pi^2$. For each 100 feet of elevation subtract 0.000596 centimetres, or 0.000235 inches, or .0000196 feet.

LENGTH OF THE SECONDS PENDULUM.*

Date of determination.	Number of observation stations.	Range of latitude included by the stations.	Length of pendulum in metres for latitude ϕ.	Corresponding length of pendulum for lat. 45°.	Reference.
1799	15	From $+67° 05'$ to $-33° 56'$	$0.990631 + .005637 \sin^2\phi$	0.993450	1
1816	31	" $+74° 53'$ " $-51° 21'$	$0.990743 + .005466 \sin^2\phi$	0.993976	2
1821	8	" $+38° 40'$ " $-60° 45'$	$0.990880 + .005340 \sin^2\phi$	0.993550	3
1825	25	" $+79° 50'$ " $-12° 59'$	$0.990977 + .005142 \sin^2\phi$	0.993548	4
1827	41	" $+79° 50'$ " $-51° 35'$	$0.991026 + .005072 \sin^2\phi$	0.993562	5
1829	5	" $0° 0'$ " $+67° 04'$	$0.990555 + .005679 \sin^2\phi$	0.993395	6
1830	49	" $+79° 51'$ " $-51° 35'$	$0.991017 + .005087 \sin^2\phi$	0.993560	7
1833	–	" — " —	$0.990941 + .005142 \sin^2\phi$	0.993512	8
1869	51	" $+79° 50'$ " $-51° 35'$	$0.990970 + .005185 \sin^2\phi$	0.993554†	9
1876	73	" $+79° 50'$ " $-62° 56'$	$0.991011 + .005105 \sin^2\phi$	0.993563	10
1884	123	" $+79° 50'$ " $-62° 56'$	$0.990918 + .005262 \sin^2\phi$	0.993549	11
Combining the above results			$0.990910 + .005290 \sin^2\phi$	0.993555	12

In 1884, from the series of observations used by Dr. Fischer, Dr. G. W. Hill[13] found

$$\begin{aligned}
l = {} & 0.9927148 \text{ metre} \\
& + 0.0050890\,\rho^{-4}(\sin^2\phi - \tfrac{1}{3}) \\
& + 0.0000979\,\rho^{-4}\cos^2\phi\cos(2\omega' + 29°\,04') \\
& - 0.0001355\,\rho^{-5}(\sin^3\phi - \tfrac{3}{5}\sin)\phi \\
& + 0.0005421\,\rho^{-5}(\sin^2\phi - \tfrac{1}{5})\cos\phi\cos(\omega' + 217°\,51') \\
& + 0.0002640\,\rho^{-5}\sin\phi\cos^2\phi\cos(2\omega' + 4°\,49') \\
& + 0.0001248\,\rho^{-5}\cos^3\phi\cos(3\omega' + 110°\,24') \\
& + 0.0001489\,\rho^{-6}(\sin^4\phi - \tfrac{6}{7}\sin^2\phi + \tfrac{3}{35}) \\
& + 0.0007386\,\rho^{-6}(\sin^3\phi - \tfrac{3}{7}\sin\phi)\cos\phi\cos(\omega' + 3°\,02') \\
& + 0.0002175\,\rho^{-6}(\sin^2\phi - \tfrac{1}{7})\cos^2\phi\cos(2\omega' + 262°\,17') \\
& + 0.0003126\,\rho^{-6}\sin\phi\cos^3\phi\cos(3\omega' + 148°\,20') \\
& + 0.0000584\,\rho^{-6}\cos^4\phi\cos(4\omega' + 248°\,19')
\end{aligned}$$

where ϕ is the geocentric latitude, ω' the geographical longitude, and ρ a factor, varying with the latitude, such that the radius of the earth at latitude ϕ is $a\rho$ where a is the equatorial radius of the earth.

1 Laplace: "Traité de Mécanique Céleste," T. 2, livre 3, chap. 5, sect. 42.
2 Mathieu: "Sur les expériences du pendule;" in "Connaissance des Temps 1816," Additions, pp. 314–341, p. 332.
3 Biot et Arago: "Recueil d'Observations géodésiques, etc." Paris, 1821, p. 575.
4 Sabine: "An Account of Experiments to determine the Figure of the Earth, etc., by Sir Edward Sabine." London, 1825, p. 352.
5 Saigey: "Comparaison des Observations du pendule à diverses latitudes; faites par MM. Biot, Kater, Sabine, de Freycinet, et Duperry;" in "Bulletin des Sciences Mathématiques, etc.," T. 1, pp. 31–43, and 171–184. Paris, 1827.
6 Pontécoulant: "Théorie analytique du Système du monde," Paris, 1829, T. 2, p. 466.
7 Airy: "Figure of the Earth;" in "Encyc. Met." 2d Div. vol. 3, p. 230.
8 Poisson: "Traité de Mécanique," T. 1, p. 377; "Connaissance des Temps," 1834, pp. 32–33; and Puissant: "Traité de géodésie," T. 2, p. 464.
9 Unferdinger: "Das Pendel als geodätisches Instrument;" in Grunert's "Archiv," 1869, p. 316.
10 Fischer: "Die Gestalt der Erde und die Pendelmessungen;" in "Ast. Nach." 1876, col. 87.
11 Helmert: "Die mathematischen und physikalischen Theorieen der höheren Geodäsie, von Dr. F. R. Helmert," II. Theil. Leipzig, 1884, p. 241.
12 Harkness.
13 Hill, Astronomical paper prepared for the use of the "American Ephemeris and Nautical Almanac," vol. 3, p. 339.

* The data here given with regard to the different determinations which have been made of the length of the seconds pendulum are quoted from Harkness (Solar Parallax and its Related Constants, Washington, 1891).
† Calculated from a logarithmic expression given by Unferdinger.

MISCELLANEOUS DATA WITH REGARD TO THE EARTH AND PLANETS.*

Length of the seconds pendulum at sea level . . . . $= l = 39.012540 + 0.208268 \sin^2 \phi$ inches.
$= 3.251045 + 0.017356 \sin^2 \phi$ feet.
$= 0.9909910 + 0.005290 \sin^2 \phi$ metres.

Acceleration produced by gravity per second per second mean solar time . . $= g = 32.086528 + 0.171293 \sin^2 \phi$ feet.
$= 977.9800 + 5.2210 \sin^2 \phi$ centimetres.

Equatorial semidiameter . . . . . $= a = 20925293 \pm 409.4$ feet.
$= 3963.124 \pm 0.078$ miles.
$= 6377972 \pm 124.8$ metres.

Polar semidiameter . . . . . . $= b = 20855590 \pm 325.1$ feet.
$= 3949.922 \pm 0.062$ miles.
$= 6356727 \pm 99.09$ metres.

One earth quadrant . . . . . . $= 393775819 \pm 4927$ inches.
$= 32814652 \pm 410.6$ feet.
$= 6214.896 \pm 0.078$ miles.
$= 10001816 \pm 125.1$ metres.

Flattening $= \dfrac{a-b}{a} = \dfrac{1}{300.205 \pm 2.964}$

Eccentricity $= \dfrac{a^2 - b^2}{a^2} = 0.006651018.$

Difference between geographical and geocentric latitude $= \phi - \phi'$
$= 688.2242'' \sin 2\phi - 1.1482'' \sin 4\phi + 0.0026'' \sin 6\phi.$

Mean density of the Earth $= 5.576 \pm 0.016.$

Surface density of the Earth $= 2.56 \pm 0.16.$

Moments of inertia of the Earth; the principal moments being taken as A, B, and C, and C the greater:

$$\frac{C-A}{C} = 0.00326521 = \frac{1}{306.259};$$
$$C - A = 0.001064767\, Ea^2;$$
$$A = B = 0.325029\, Ea^2;$$
$$C = 0.326094\, Ea^2;$$

where E is the mass of the Earth and a its equatorial semidiameter.

Length of sidereal year $= 365.2563578$ mean solar days;
$= 365$ days 6 hours 9 minutes 9.314 seconds.

Length of tropical year
$= 365.242199870 - 0.0000062124 \dfrac{t - 1850}{100}$ mean solar days;
$= 365$ days 5 hours 48 minutes $\left(46.069 - 0.53675 \dfrac{t - 1850}{100}\right)$ seconds.

Length of sidereal month
$= 27.321661162 - 0.00000026240 \dfrac{t - 1800}{100}$ days;
$= 27$ days 7 hours 43 minutes $\left(11.524 - 0.022671 \dfrac{t - 1800}{100}\right)$ seconds.

Length of synodical month
$= 29.530588435 - 0.00000030696 \dfrac{t - 1800}{100}$ days;
$= 29$ days 12 hours 44 minutes $\left(2.841 - 0.026522 \dfrac{t - 1800}{100}\right)$ seconds.

Length of sidereal day $= 86164.09965$ mean solar seconds.

N. B. — The factor containing t in the above equations (the epoch at which the values of the quantities are required) may in all ordinary cases be neglected.

* Harkness, "Solar Parallax and Allied Constants."

MISCELLANEOUS DATA WITH REGARD TO THE EARTH AND PLANETS.

MASSES OF THE PLANETS.

Reciprocals of the masses of the planets relative to the Sun and of the mass of the Moon relative to the Earth:

Mercury	$= 8374672 \pm 1765762.$
Venus	$= 408968 \pm 1874.$
Earth *	$= 327214 \pm 624.$
Mars	$= 3093500 \pm 3295.$
Jupiter	$= 1047.55 \pm 0.20.$
Saturn	$= 3501.6 \pm 0.78.$
Uranus	$= 22600 \pm 36.$
Neptune	$= 18780 \pm 300.$
Moon	$= 81.068 \pm 0.238.$

Mean distance from Earth to Sun $= 92796950 \pm 59715$ miles;
$= 149340870 \pm 96101$ kilometres.

Eccentricity of Earth's orbit $= e_1$

$$= 0.016771049 - 0.0000004245\,(t - 1850) - 0.000000001367\left(\frac{t - 180}{100}\right)^2.$$

Solar parallax $= 8.80905'' \pm 0.00567''$.

Lunar parallax $= 3422.54216'' \pm 0.12533''$.

Mean distance from Earth to Moon $= 60.269315 \pm 0.002502$ terrestrial radii;
$= 238854.75 \pm 9.916$ miles;
$= 384396.01 \pm 15.958$ kilometres.

Lunar inequality of the Earth $= L = 6.52294'' \pm 0.01854''$.

Parallactic inequality of the Moon $= Q = 124.95126'' \pm 0.08197''$.

Mean motion of Moon's node in 365.25 days $= \mu = -19^\circ\, 21'\, 19.6191'' + 0.14136''\,\dfrac{t - 1800}{100}$.

Eccentricity and inclination of the Moon's orbit $= e_2 = 0.054899720$.

Delaunay's $\gamma = \sin \frac{1}{2} I = 0.044886793$.
$I = 5^\circ\, 08'\, 43.3546''$.

Constant of nutation $= 9.22054'' \pm 0.00859'' + 0.00000904''\,(t - 1850)$.

Constant of aberration $= 20.45451'' \pm 0.01258''$.

Time taken by light to traverse the mean radius of the Earth's orbit
$= 498.00595 \pm 0.30834$ seconds.

Velocity of light $= 186337.00 \pm 49.722$ miles per second.
$= 299877.64 \pm 80.019$ kilometres per second.

* Earth + Moon.

AERODYNAMICS.

The pressure on a plane surface normal to the wind is for ordinary wind velocities expressed by

$$P = kwav^2$$

where k is a constant depending on the units employed, w the mass of unit volume of the air, a the area of the surface and v the velocity of the wind.* Engineers generally use the table of values of P given by Smeaton in 1759. This table was calculated from the formula

$$P = .00492\,v^2$$

and gives the pressure in pounds per square foot when v is expressed in miles per hour. The corresponding formula when v is expressed in feet per second is

$$P = .00228\,v^2.$$

Later determinations do not agree well together, but give on the average somewhat lower values for the coefficient. The value of w depends, of course, on the temperature and the barometric pressure. Langley's † experiments give $kw = .00166$ at ordinary barometric pressure and 10° C. temperature.

For planes inclined at an angle a less than 90° to the direction of the wind the pressure may be expressed as

$$P_a = F_a P_{90}.$$

Table 118, founded on the experiments of Langley, gives the value of F_a for different values of a. The word *aspect*, in the headings, is used by him to define the position of the plane relative to the direction of motion. The numerical value of the aspect is the ratio of the linear dimension transverse to the direction of motion to the linear dimension, a vertical plane through which is parallel to the direction of motion.

TABLE 118. — Values of F_a in Equation $P_a = F_a P_{90}$.

Plane 30 in. × 4.8 in. Aspect 6 (nearly).		Plane 12 in. × 12 in. Aspect 1.		Plane 6 in. × 24 in. Aspect ¼.	
a	F_a	a	F_a	a	F_a
0°	0.00	0°	0.00	0°	0.00
5	0.28	5	0.15	5	0.07
10	0.44	10	0.30	10	0.17
15	0.55	15	0.44	15	0.29
20	0.62	20	0.57	20	0.43
25	0.66	25	0.69	25	0.58
30	0.69	30	0.78	30	0.71
35	0.72	35	0.84	-	-
40	0.74	40	0.88	-	-
45	0.76	45	0.91	-	-
50	0.78	50	-	-	-

* The pressure on a spherical surface is approximately 0.36 that on a plane circular surface of the same diameter as the sphere; on a cylindrical surface with axis normal to the wind, about 0.5 that on a rectangular surface of length equal to the length, and breadth equal to the diameter of the cylinder.

† The data here given on Professor Langley's authority were communicated by him to the author.

AERODYNAMICS.

On the basis of the results given in Table 118 Langley states the following condition for the soaring of an aeroplane 76.2 centimetres long and 12.2 centimetres broad, weighing 500 grammes, — that is, a plane one square foot in area, weighing 1.1 pounds. It is supposed to soar in a horizontal direction, with aspect 6.

TABLE 119. — Data for the Soaring of Planes 76.2 × 12.2 cms. weighing 500 Grammes, Aspect 6.

Inclination to the horizontal α.	Soaring speed v.		Work expended per minute (activity).		Weight of planes of like form, capable of soaring at speed v with the expenditure of one horse power.	
	Metres per sec.	Feet per sec.	Kilogramme metres.	Foot pounds.	Kilogrammes.	Pounds.
2°	20.0	66	24	174	95.0	209
5	15.2	50	41	297	55.5	122
10	12.4	41	65	474	34.8	77
15	11.2	37	86	623	26.5	58
30	10.6	35	175	1268	13.0	29
45	11.2	37	336	2434	6.8	15

$$\text{In general, if } \rho = \frac{\text{weight}}{\text{area}}$$

$$\text{Soaring speed } v = \sqrt{\frac{\rho}{k} \cdot \frac{1}{F_\alpha \cos \alpha}}$$

$$\text{Activity per unit of weight} = v \tan \alpha$$

The following data for curved surfaces are due to Wellner (Zeits. für Luftschifffahrt, x., Oct. 1893).

Let the surface be so curved that its intersection with a vertical plane parallel to the line of motion is a parabola whose height is about $\frac{1}{12}$ the subtending chord, and let the surface be bounded by an elliptic outline symmetrical with the line of motion. Also, let the angle of inclination of the chord of the surface be α, and the angle between the direction of resultant air pressure and the normal to the direction of motion be β. Then $\beta < \alpha$, and the soaring speed is $v = \sqrt{\frac{\rho}{k} \cdot \frac{1}{F_\alpha \cos \beta}}$, while the activity per unit of weight $= v \tan \beta$.

The following series of values were obtained from experiments on moving trains and in the wind.

Angle of inclination $\alpha =$	$-3°$	0°	$+3°$	6°	9°	12°
Inclination factor $F_\alpha =$	0.20	0.50	0.75	0.90	1.00	1.05
$\tan \beta =$	0.01	0.02	0.03	0.04	0.10	0.17

Thus a curved surface shows finite soaring speeds when the angle of inclination α is zero or even slightly negative. Above $\alpha = 12°$ curved surfaces rapidly lose any advantage they may have for small inclinations.

TABLE 120. — Total Intensity of the Terrestrial Magnetic Field.

This table gives in the top line the total intensity of the terrestrial magnetic field for the longitudes given in the first column and the latitudes given in the body of the table. Under the headings 13, 13.5, and 13.75 there are sometimes several entries for one longitude. This indicates that these lines of total force cut the same longitude line more than once. The isodynamic lines are peculiarly curved and looped north of Lake Ontario. The values are for the epoch January 1, 1885, and the intensities are in British and C. G. S. units.

Longitude.	10.5 or .4841	11.0 or .5072	11.5 or .5304	12.0 or .5533	12.5 or .5764	13.0 or .5994		13.5 or .6225				13.75 or .6340	
°	°	°	°	°	°	°	°	°	°	°	°	°	°
67	-	-	-	-	-	44.5	45.5	-	-	-	-	-	-
68	-	-	-	-	-	43.1	48.2	-	-	-	-	-	-
70	-	-	-	-	-	41.9	-	-	-	-	-	-	-
72	-	-	-	-	-	40.6	-	-	-	-	-	-	-
75	-	-	-	-	-	36.7	-	-	-	-	-	-	-
76	-	-	-	-	-	36.4	-	44.7	-	-	-	-	-
77	-	-	-	-	-	36.0	-	43.6	45.4	-	-	-	-
78	-	22.6	24.5	-	-	34.1	-	43.3	45.2	-	-	-	-
80	-	22.8	24.5	27.9	31.2	35.1	-	43.9	44.6	-	-	-	-
81	-	22.8	24.5	27.1	31.2	35.5	-	41.4	41.9	44.3	45.8	-	-
82	-	22.8	24.6	26.4	31.3	35.5	-	41.2	42.1	43.6	45.8	-	-
83	-	22.7	24.8	26.6	31.2	35.2	-	41.0	46.2	-	-	-	-
85	19.6	22.2	25.0	27.9	30.8	34.4	-	40.8	47.6	-	-	45.5	46.1
86	19.8	22.3	-	28.3	30.6	35.3	-	41.1	48.0	-	-	45.2	47.4
87	20.0	22.5	-	28.6	30.4	35.5	-	41.9	48.4	-	-	43.2	47.7
90	20.1	22.5	-	29.9	31.9	36.6	-	41.6	49.1	-	-	43.2	48.2
92	20.1	22.3	-	29.3	33.3	37.4	-	41.7	50.2	-	-	44.7	48.2
95	20.0	22.3	-	28.3	33.1	37.2	-	41.2	-	-	-	43.7	-
100	20.0	22.8	-	30.0	34.1	39.0	-	41.4	-	-	-	42.7	-
105	21.7	24.4	-	33.1	36.1	39.8	-	43.6	-	-	-	44.8	-
110	23.2	26.9	31.2	34.4	37.7	41.6	-	45.2	-	-	-	47.0	-
115	-	29.1	31.8	35.2	40.1	44.5	-	-	-	-	-	-	-
120	-	30.7	34.7	37.8	42.3	46.4	-	-	-	-	-	-	-
124	-	-	-	39.6	44.2	-	-	-	-	-	-	-	-

TABLE 121. — Secular Variation of the Total Intensity.

Values in British units of total intensity of terrestrial magnetic force at stations given in the first column and epochs January 1 of the years given in the top line.

Station.	1840	1845	1850	1855	1860	1865	1870	1875	1880	1885
Cambridge . .	13.48	13.33	13.21	13.22	13.37	13.45	13.49	13.39	13.14	12.79
New Haven .	13.47	13.40	13.25	13.11	13.20	13.33	13.41	13.41	13.29	13.05
New York .	13.56	13.51	13.39	13.27	13.32	13.36	13.36	13.31	13.19	12.99
Sandy Hook .	13.70	13.59	13.36	13.17	13.23	13.35	13.40	13.39	13.30	13.13
Albany . .	13.68	13.65	13.72	13.80	13.87	13.93	13.92	13.82	13.61	13.27
Philadelphia .	13.52	13.44	13.45	13.47	13.51	13.55	13.58	13.57	13.49	13.25
Baltimore . .	13.56	13.45	13.38	13.37	13.44	13.46	13.48	13.48	13.38	13.22
Washington .	13.43	13.36	13.31	13.34	13.39	13.42	13.42	13.38	13.29	13.20
Toronto . .	14.03	13.93	13.95	13.91	13.82	13.82	13.77	13.78	13.78	13.76
Cleveland .	13.85	13.78	13.76	12.75	13.78	13.83	13.84	13.81	13.74	13.61
Detroit . . .	13.85	13.80	13.71	13.68	13.72	13.75	13.76	13.78	13.73	13.62

* Tables 120–125 have been compiled from a very full discussion of the magnetic dip and intensity for the United States and adjacent countries, given in Appendix 6 of the Report of the United States Coast and Geodetic Survey for 1885. Later Reports of the survey have been consulted, particularly in connection with the extrapolation of the values of horizontal intensity to 1890 and 1895, but most of the data are taken from Mr. Schott's Appendix to the 1885 Report.

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TABLE 122. — Values of the Magnetic Dip.

This table gives for the epoch January 1, 1885, the values of the magnetic dip, stated in first column, corresponding to the longitudes given in the top line and the latitudes given in the body of the table. Thus, for longitude 95° and latitude 30° the dip was 59° on January 1, 1885. The longitudes are west of Greenwich. For positions above the division line in the table the dip was increasing, and for positions below that line decreasing, in 1885.

Dip.	Longitudes west of Greenwich.												
	66°	70°	75°	80°	85°	90°	95°	100°	105°	110°	115°	120°	124°
°	°	°	°	°	°	°	°	°	°	°	°	°	°
44	-	-	-	-	-	17.9	18.4	19.1	19.6	-	-	-	-
45	-	-	-	-	-	18.7	19.2	19.8	20.3	-	-	-	-
6	-	-	-	-	-	19.2	19.8	20.6	21.1	-	-	-	-
7	-	-	-	-	-	20.0	20.5	21.2	21.8	-	-	-	-
8	-	-	17.9	-	-	20.5	21.2	21.9	22.5	23.3	-	-	-
9	-	-	18.7	-	-	21.2	21.9	22.6	23.2	24.0	-	-	-
50	-	-	-	-	21.4	22.1	22.7	23.5	24.1	24.7	-	-	-
1	-	-	-	-	22.2	22.8	23.6	24.3	24.8	25.5	-	-	-
2	-	-	-	22.4	23.0	23.7	24.4	25.1	25.6	26.3	27.4	-	-
3	-	-	-	23.3	23.9	24.5	25.2	25.9	26.5	27.1	28.2	-	-
4	-	-	-	24.0	24.7	25.3	26.0	26.7	27.2	28.1	29.0	-	-
55	-	-	-	24.8	25.5	26.1	26.8	27.5	28.1	28.9	29.9	-	-
6	-	-	24.7	25.6	26.3	26.9	27.5	28.1	28.9	29.7	30.6	-	-
7	-	-	-	26.4	27.1	27.7	28.3	28.9	29.7	30.6	31.4	-	-
8	-	-	-	27.3	27.9	28.5	29.1	29.8	30.5	31.4	32.3	-	-
9	-	-	-	28.0	28.7	29.4	30.0	30.6	31.5	32.4	33.3	34.4	-
60	-	-	-	28.6	29.6	30.2	30.8	31.5	32.4	33.4	34.3	35.3	-
1	-	-	-	29.9	30.3	30.9	31.7	32.4	33.3	34.2	35.3	36.2	-
2	-	-	-	30.6	31.3	31.9	32.5	33.3	34.3	35.2	36.3	37.1	-
3	-	-	-	31.6	32.0	32.7	33.6	34.2	35.2	36.2	37.1	38.1	39.0
4	-	-	-	32.7	33.2	33.6	34.5	35.2	36.1	37.2	38.1	39.0	40.3
65	-	-	-	33.5	34.0	34.6	35.5	36.2	37.1	38.2	39.2	40.3	41.5
6	-	-	-	34.3	35.0	35.8	36.5	37.2	38.1	39.2	40.3	41.5	42.5
7	-	-	35.1	35.3	35.9	36.6	37.2	38.2	39.1	40.2	41.4	42.5	43.6
8	-	-	35.8	36.0	36.6	37.5	38.2	39.2	40.0	41.2	42.4	43.6	44.7
9	-	-	37.0	37.5	37.6	38.5	39.2	40.0	41.2	42.2	43.5	44.6	45.7
70	-	-	38.0	38.5	39.0	39.6	40.4	41.0	42.1	43.3	44.5	45.6	46.9
1	-	-	39.1	39.5	39.8	40.7	41.1	41.8	43.2	44.3	45.7	47.2	47.9
2	-	-	40.4	40.3	40.9	41.6	42.1	43.1	44.3	45.5	47.1	48.6	49.2
3	-	41.7	41.2	41.9	42.2	42.7	43.4	44.4	45.5	46.9	48.6	50.0	-
4	43.5	43.1	42.9	43.1	43.4	43.9	44.5	45.6	46.7	48.3	49.7	-	-
75	44.9	44.5	44.3	44.0	44.5	45.0	45.7	46.7	48.0	49.5	51.0	-	-
6	45.7	45.9	45.5	45.4	45.5	46.1	47.1	48.2	49.5	50.7	-	-	-
7	47.3	47.6	46.7	46.9	47.0	47.4	48.3	49.4	50.6	-	-	-	-
8	-	-	-	48.2	48.0	48.8	49.7	50.7	51.8	-	-	-	-
9	-	-	-	49.3	49.3	-	51.0	51.9	-	-	-	-	-
80	-	-	-	50.4	50.4	-	-	-	-	-	-	-	-

TABLE 123. — Secular Variation of the Magnetic Dip.

Values of magnetic dip at stations given in the first column, and epochs, January 1, of the years given in the top line.

Station.	1840	1845	1850	1855	1860	1865	1870	1875	1880	1885
Cambridge .	74.25	74.29	74.35	74.40	74.42	74.38	74.26	74.02	73.65	73.12
New Haven	73.47	73.51	73.56	73.61	73.64	73.62	73.54	73.38	73.11	72.72
New York .	72.75	72.73	72.75	72.78	72.80	72.78	72.71	72.56	72.31	71.93
Sandy Hook	72.63	72.61	72.63	72.66	72.68	72.66	72.59	72.44	72.19	71.81
Albany . .	74.75	74.80	74.88	74.96	75.02	75.02	74.95	74.77	74.46	73.99
Philadelphia	71.99	72.02	72.08	72.15	72.20	72.21	72.16	72.02	71.77	71.38
Baltimore .	71.74	71.66	71.66	71.69	71.74	71.77	71.76	71.67	71.48	71.16
Washington	71.39	71.39	71.38	71.36	71.32	71.25	71.15	71.00	70.80	70.55
Toronto . .	75.28	75.25	75.32	75.39	75.41	75.35	75.27	75.20	75.03	74.88
Cleveland .	73.22	73.19	73.21	73.24	73.28	73.29	73.27	73.18	73.03	72.78
Detroit . .	73.61	73.61	73.63	73.66	73.68	73.69	73.67	73.60	73.47	73.28

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TABLE 124. — Horizontal Intensity.

This table gives, for the epoch January 1, 1885, the horizontal intensity, *H*, corresponding to the longitudes in the top line and the latitudes in the body of the table. At epoch 1885 the force was increasing for positions above the division line, and was decreasing for positions below the division line.

H in British units.	Longitudes west of Greenwich. 65°	70°	75°	80°	85°	90°	95°	100°	105°	110°	115°	120°	124°	*H* in C.G.S. units.
	°	°	°	°	°	°	°	°	°	°	°	°	°	
2.50	–	–	–	–	49.8	–	–	–	–	–	–	–	–	**.1153**
2.75	–	–	–	48.5	48.8	49.8	–	–	–	–	–	–	–	.1268
3.00	48.3	47.3	46.6	47.2	47.6	48.5	49.1	50.1	–	–	–	–	–	.1383
3.25	45.5	45.6	45.5	45.8	46.1	46.7	47.6	48.5	–	–	–	–	–	.1498
3.50	43.2	43.8	43.6	44.0	44.6	45.1	45.8	47.2	–	–	–	–	–	.1614
3.75	–	42.2	42.5	42.6	43.2	43.6	44.6	45.8	47.3	48.4	49.4	–	–	**.1729**
4.00	–	40.7	41.2	41.5	42.1	42.4	43.4	44.6	45.7	46.8	47.7	48.7	49.6	.1844
4.25	–	–	39.6	40.2	40.4	41.0	41.8	43.0	44.2	45.4	46.3	47.0	47.6	.1959
4.50	–	–	38.1	38.7	39.2	39.7	40.4	41.6	42.8	43.8	44.6	45.2	45.7	.2075
4.75	–	–	36.6	37.4	37.6	38.4	39.1	39.9	41.0	42.0	42.8	43.6	44.2	.2190
5.00	–	–	35.1	35.8	36.2	36.9	37.8	38.5	39.3	40.3	41.1	41.9	42.6	**.2305**
5.25	–	–	–	34.6	35.2	35.4	35.9	37.0	38.0	37.7	39.2	39.6	39.8	.2422
5.50	–	–	–	33.0	33.8	33.8	34.5	35.3	36.3	36.7	37.2	37.7	37.4	.2536
5.75	–	–	–	31.0	32.2	32.1	32.7	33.6	34.7	34.8	35.2	35.6	–	.2651
6.00	–	–	–	28.8	30.6	30.3	31.0	31.6	31.9	32.3	33.1	33.6	–	.2766
6.25	–	–	–	27.4	29.2	28.1	29.8	29.9	–	–	31.1	–	–	**.2881**
6.50	–	–	24.1	25.8	27.3	27.3	27.7	28.0	28.2	28.4	28.6	–	–	.2997
6.75	–	–	–	23.6	–	–	–	–	–	26.1	–	–	–	.3112
7.00	–	–	18.2	20.8	22.1	22.5	22.8	23.0	23.2	24.0	–	–	–	.3228
7.25	–	–	–	–	–	19.5	19.9	20.3	20.5	21.2	–	–	–	.3343

TABLE 125. — Secular Variation of the Horizontal Intensity.

Values of the horizontal intensity, *H*, in British units, for stations given in first column and epochs given in top line. The values for 1890 and 1895 have been extrapolated from the values up to 1885. The epochs are for January 1 of the different years given.

Station.	1840	1845	1850	1855	1860	1865	1870	1875	1880	1885	1890	1895
Cambridge . .	3.66	3.61	3.56	3.55	3.59	3.62	3.66	3.68	3.70	3.71	3.73	3.74
New Haven . .	3.83	3.80	3.75	3.70	3.72	3.76	3.80	3.83	3.86	3.87	3.87	3.86
New York . .	4.02	4.01	3.97	3.93	3.94	3.95	3.97	3.99	4.01	4.03	4.05	4.07
Sandy Hook .	4.09	4.06	3.99	3.92	3.94	3.98	4.01	4.04	4.07	4.10	4.13	4.16
Albany . . .	3.60	3.58	3.58	3.58	3.58	3.60	3.61	3.63	3.64	3.66	3.67	3.69
Philadelphia .	4.18	4.15	4.14	4.13	4.13	4.14	4.16	4.19	4.22	4.23	4.24	4.24
Baltimore . .	4.25	4.23	4.21	4.20	4.21	4.21	4.22	4.24	4.25	4.27	4.28	4.30
Washington .	4.28	4.26	4.25	4.26	4.29	4.31	4.33	4.35	4.37	4.39	4.41	4.42
Toronto . . .	3.56	3.54	3.53	3.51	3.48	3.49	3.50	4.52	3.56	3.58	4.60	4.61
Cleveland . .	4.00	3.98	3.97	3.96	3.96	3.97	3.98	3.99	4.01	4.03	4.05	4.07
Detroit . . .	3.91	3.89	3.86	3.85	3.85	3.86	3.87	3.89	3.90	3.92	3.93	3.94
San Diego . .	6.12	6.19	6.22	6.25	6.26	6.24	6.20	6.15	6.10	6.07	6.04	6.03
Santa Barbara .	5.87	5.93	5.94	5.95	5.96	5.95	5.94	5.92	5.88	5.84	5.80	5.77
Monterey . .	5.63	5.71	5.75	5.77	5.76	5.75	5.72	5.69	5.66	5.65	5.64	5.63
San Francisco .	5.49	5.54	5.56	5.57	5.59	5.59	5.58	5.54	5.51	5.49	5.47	5.45
Fort Vancouver	4.44	4.51	4.55	4.56	4.58	4.58	4.57	4.56	4.54	4.53	4.52	4.52

TERRESTRIAL MAGNETISM.

Secular Variation of Declination in the Form of a Function of the Time for a Number of Stations.

More extended tables will be found in App. 7 of the United States Coast and Geodetic Survey Report for 1888, from which this table has been compiled. The variable m is reckoned from the epoch 1850 and thus $= t - 1850$.

Station.	Latitude.	West longitude.	The magnetic declination (D) expressed as a function of time.
(a) Eastern Series of Stations.			
	° ′	° ′	° ° °
St. Johns, N. F.	47 34.4	52 41.9	$21.94 + 8.89 \sin(1.05m + 63.4)$*
Quebec, Canada	46 48.4	71 14.5	$14.66 + 3.03 \sin(1.4m + 4.6)$
			$+ 0.61 \sin(4.0m + 0.3)$
Charlottetown, P. E. I.	46 14.0	63 27.0	$15.95 + 7.78 \sin(1.2m + 49.8)$
Montreal, Canada	45 30.5	73 34.6	$11.88 + 4.17 \sin(1.5m - 18.5)$
			$+ 0.36 \sin(4.9m + 19.0)$
Bangor, Me.	44 82.2	68 46.9	$13.86 + 3.55 \sin(1.30m + 8.6)$
Halifax, N. S.	44 39.6	63 35.3	$16.18 + 4.53 \sin(1.00m + 46.1)$*
Albany, N. Y.	42 39 2	73 45.8	$8.17 + 3.02 \sin(1.44m - 8.3)$
Cambridge, Mass.	42 22.9	71 07.7	$9.54 + 2.69 \sin(1.30m + 7.0)$
			$+ 0.18 \sin(3.20m + 44.0)$
New Haven, Conn.	41 18.5	72 55.7	$7.78 + 3.11 \sin(1.40m - 22.1)$
New York, N. Y.	40 42.7	74 00.4	$7.04 + 2.77 \sin(1.30m - 18.1)$
			$+ 0.14 \sin(6.30m + 64.0)$
Harrisburg, Pa.	40 15.9	70 52.6	$2.93 + 2.98 \sin(1.50m + 0.2)$
Philadelphia, Pa.	39 56.9	75 09.0	$5.36 + 3.17 \sin(1.50m - 26.1)$
			$+ 0.19 \sin(4.00m + 14.6)$
Washington, D. C.	38 53.3	77 00.6	$2.73 + 2.57 \sin(1.45m - 21.6)$
			$+ 0.14 \sin(12.00m + 27)$
Cape Henry, Va.	36 55.6	76 00.4	$2.42 + 2.25 \sin(1.47m - 30.6)$
Charleston, S. C.	32 46.6	70 55.8	$-1.82 + 2.75 \sin(1.40m - 12.1)$*
Paris, France	48 50.2	† 2 20.2	$6.479 + 16.002 \sin(0.765m + 118.77) + [0.85 - 0.35 \sin(0.69n)] \sin[(4.04 + 0.0054n + .000035n^2)n]$‡
St. George's Town, Bermuda	32 23.0	64 42.0	$6.95 + 0.0145m + 0.00056m^2$*
Rio de Janeiro, Brazil	−22 54.8	43 09.5	$2.19 + 9.91 \sin(0.80m - 10.4)$*
(b) Central Series of Stations.			
York Factory, B. N. A.	56 59.9	92 26.0	$7.34 + 16.03 \sin(1.10m - 97.9)$
Fort Albany, B. N. A.	52 22.0	82 38.0	$15.78 + 6.95 \sin(1.20m - 99.6)$*
Sault Ste Marie, Mich.	46 29.9	84 20.1	$1.54 + 2.70 \sin(1.45m - 58.5)$
Toronto, Canada	43 39.4	79 23.5	$3.60 + 2.82 \sin(1.40m - 44.7)$
			$+ 0.09 \sin(9.30m + 136)$
			$+ 0.08 \sin(19.00m + 247)$
Chicago, Ill.	41 50.0	87 36.8	$-3.77 + 2.48 \sin(1.45m - 62.5)$
Cleveland, Ohio	41 30.4	81 41.5	$0.47 + 2.39 \sin(1.30m - 14.8)$
Denver, Colo.	39 45.3	104 59.5	$-15.30 + 0.011m + 0.0005m^2$
Athens, Ohio	39 19.0	82 02.0	$-1.51 + 2.63 \sin(1.40m - 24.7)$
Cincinnati, Ohio	39 08.4	84 25.3	$-2.59 + 2.43 \sin(1.42m - 37.9)$
St. Louis, Mo.	38 38.0	90 12.2	$-5.91 + 3.00 \sin(1.40m - 51.1)$*
New Orleans, La.	29 52.2	90 03.9	$-5.20 + 2.98 \sin(1.40m - 69.8)$
Key West, Fla.	24 33.5	81 48.5	$-4.31 + 2.86 \sin(1.30m - 23.9)$
Kingston, Port Royal, Jamaica	17 55.9	76 50.6	$-3.81 + 2.39 \sin(1.10m - 10.6)$
(b) Stations on the Pacific Coast, etc.			
City of Mexico, Mex.	19 26.0	99 11.6	$-5.34 + 3.28 \sin(1.00m - 87.9)$*
Cerros Island, Lower Cal., Mex.	28 04.0	115 12.0	$-7.40 + 4.61 \sin(1.05m - 107.0)$
San Francisco, Cal.	37 47.5	122 27.3	$-13.94 + 2.65 \sin(1.05m - 135.5)$
Vancouver, Wash.	45 37.5	122 39.7	$-17.93 + 3.12 \sin(1.35m - 134.1)$
Sitka, Alaska	57 02.9	135 19.7	$-25.79 + 3.30 \sin(1.30m - 101.2)$
Port Etches, Alaska	60 20.7	146 37.6	$-23.71 + 7.89 \sin(1.35m - 80.9)$
Petropavlovsk, Siberia	53 01.0	†158 43.0	$-3.35 + 2.97 \sin(1.30m + 12.2)$

* Approximate expression. † East longitude.

‡ Compiled from a series of observations extending back to 1541. The primary wave follows the sum of the constant and first periodic term closely. The period seems to be about 470 years. In the expression for the secondary wave $n = t - 1700$.

Table 127.

TERRESTRIAL MAGNETISM.

Secular Variation of the Declination. — Eastern Stations.*

Station.	1800	1810	1820	1830	1840	1850	1860	1870	1880	1890	1900
	°	°	°	°	°	°	°	°	°	°	°
St. Johns, N. F.	23.5	25.0	26.5	28.0	29.0	29.9	35.0	30.8	30.8	30.5	29.9
Quebec, Canada	12.1	12.1	12.3	12.9	13.8	14.9	16.0	16.9	17.4	17.5	17.5
Charlottetown, P. E. I.	–	–	–	19.3	20.7	21.9	22.8	23.4	23.7	23.7	23.3
Montreal, Canada	8.0	7.8	7.9	8.4	9.4	10.7	12.0	13.0	13.8	14.4	15.0
Eastport, Me.	13.2	14.0	14.8	15.6	16.4	17.1	17.8	18.3	18.7	18.9	19.0
Bangor, Me.	10.9	11.4	12.1	12.8	13.6	14.4	15.2	15.9	16.5	16.9	17.3
Halifax, N. S.	15.9	16.7	17.4	18.2	18.9	19.4	19.9	20.3	20.6	20.7	20.7
Burlington, Vt.	7.3	7.2	7.5	8.1	8.9	9.7	10.3	11.0	11.9	12.8	13.5
Hanover, N. H.	5.8	6.0	6.5	7.2	7.9	8.8	9.8	10.8	11.7	12.5	13.1
Portland, Me.	8.5	8.9	9.5	10.1	10.8	11.6	12.3	13.0	13.6	14.1	14.4
Rutland, Vt.	6.3	6.2	6.5	6.9	7.6	8.5	9.4	10.4	11.3	12.3	13.0
Portsmouth, N. H.	7.4	7.7	8.1	8.7	9.5	10.3	11.1	11.9	12.7	13.3	13.7
Chesterfield, N. H.	–	6.0	6.4	7.0	7.7	8.5	9.4	10.3	11.2	12.0	12.6
Newburyport, Mass.	7.3	7.6	8.1	8.6	9.3	10.0	10.7	11.4	12.0	12.5	12.8
Williamstown, Mass.	5.7	5.9	6.3	6.8	7.4	8.1	8.8	9.6	10.3	10.9	11.4
Albany, N. Y.	–	5.4	5.8	6.3	7.0	7.7	8.5	9.2	9.9	10.5	10.9
Salem, Mass.	6.3	6.6	7.2	7.9	8.7	9.6	10.6	11.5	12.3	13.0	13.5
Oxford, N. Y.	3.0	3.1	3.4	3.9	4.5	5.1	5.9	6.6	7.4	8.0	8.6
Cambridge, Mass.	7.1	7.5	8.0	8.6	9.3	10.0	10.6	11.2	11.6	11.9	12.0
Boston, Mass.	6.9	7.3	7.8	8.4	9.0	9.7	10.3	10.9	11.5	11.9	12.2
Provincetown, Mass.	7.2	7.7	8.2	8.9	9.6	10.2	10.9	11.5	12.0	12.4	12.6
Providence, R. I.	6.5	6.5	6.7	7.3	8.2	9.2	9.8	10.2	10.8	11.6	12.1
Hartford, Conn.	5.2	5.2	5.5	5.8	6.2	6.8	7.4	8.0	8.6	9.2	9.8
New Haven, Conn.	4.7	4.7	5.0	5.4	5.9	6.6	7.3	8.1	8.8	9.5	10.1
Nantucket, Mass.	6.8	7.2	7.7	8.7	9.0	9.6	10.1	10.6	11.0	11.3	11.5
Cold Spring Harbor, N. Y.	4.7	4.9	5.2	5.6	6.1	6.7	7.3	7.9	8.4	8.9	9.3
New York, N. Y.	4.3	4.5	4.6	5.0	5.6	6.3	6.9	7.4	7.9	8.5	9.1
Bethlehem, Pa.	2.6	2.3	2.3	2.5	2.9	3.5	4.2	5.0	5.8	6.7	7.4
Huntingdon, Pa.	1.0	0.8	0.9	1.1	1.5	2.1	2.7	3.5	4.2	4.9	5.6
New Brunswick, N. J.	2.5	2.9	3.4	4.0	4.7	5.3	6.0	6.6	7.1	7.5	7.9
Jamesburg, N. J.	3.1	3.1	3.4	3.8	4.3	4.9	5.6	6.3	7.0	7.6	8.2
Harrisburg, Pa.	0.0	0.3	0.8	1.4	2.2	2.9	3.7	4.4	5.0	5.5	5.8
Hatboro, Pa.	1.8	2.0	2.5	3.0	3.7	4.3	5.0	5.7	6.7	7.6	8.0
Philadelphia, Pa.	2.1	2.2	2.4	2.9	3.4	4.1	4.7	5.4	6.2	7.0	7.7
Chambersburg, Pa.	−0.3	−0.5	−0.3	0.2	0.7	1.4	2.0	2.7	3.4	4.2	5.0
Baltimore, Md.	0.6	0.7	0.9	1.2	1.7	2.3	2.9	3.5	4.2	4.7	5.2
Washington, D. C.	0.2	0.2	0.4	0.7	1.1	1.8	2.5	2.9	3.7	4.3	4.6
Cape Henlopen, Del.	0.8	0.9	1.1	1.5	2.0	2.6	2.4	4.1	4.9	5.6	6.2
Williamsburg, Va.	−0.2	−0.3	−0.2	0.0	0.4	0.9	1.5	2.1	2.7	3.3	3.9
Cape Henry, Va.	0.2	0.2	0.2	0.5	0.8	1.3	1.8	2.4	2.9	3.5	3.9
New Berne, N. C.	−1.9	−1.9	−1.6	−1.2	−0.7	−0.2	0.5	1.1	1.7	2.3	2.7
Milledgeville, Ga.	−5.0	−5.3	−5.6	−5.6	−5.5	−5.3	−5.0	−4.5	−4.0	−3.4	−2.7
Charleston, S. C.	−4.5	−4.4	−4.0	−3.6	−3.0	−2.4	−1.7	−1.1	−0.4	0.1	0.5
Savannah, Ga.	–	−4.7	−4.7	−4.5	−4.2	−3.8	−3.3	−2.7	−2.1	−1.4	−0.9
Paris, France	22.6	22.3	21.9	21.8	21.8	20.9	19.1	17.5	16.6	15.1	
St. George's Town, B. I.	–	–	–	6.9	6.9	6.9	7.1	7.5	7.9	8.4	
Rio de Janeiro, Brazil	−5.4	−4.5	−3.4	−2.2	−0.9	0.4	1.8	3.1	4.5	5.8	

* This table gives the secular variation of the declination since the year 1800 for a series of stations in the Eastern States and adjacent countries. Compiled from a paper by Mr. Schott, forming App. 7, Report of the United States Coast and Geodetic Survey for 1888. The minus sign indicates eastern declination.

TERRESTRIAL MAGNETISM.

Secular Variation of the Declination. — Central Stations.*

Station.	1800	1810	1820	1830	1840	1850	1860	1870	1880	1890	1900
York Factory, Brit. N. A.	0.1	−2.5	−4.7	−6.5	−7.8	−8.5	−8.6	−8.2	−7.2	−5.6	−3.6
Fort Albany, Brit. N. A.	13.4	12.1	10.9	10.0	9.3	8.9	8.8	9.1	9.6	10.3	11.4
Duluth, Minn. / Superior City, Wis.	–	–	–	–	–	−9.8	−10.0	−10.1	−10.1	−9.9	−9.5
Sault Ste. Marie, Mich.	−0.5	−0.9	−1.1	−1.6	−1.0	−0.8	−0.3	0.2	0.8	1.5	2.2
Pierrepont Manor, N. Y.	–	–	2.6	3.0	3.7	4.5	5.4	6.3	7.2	8.0	8.8
Toronto, Canada	–	–	–	0.8	1.3	1.6	2.2	2.7	3.6	4.1	4.8
Grand Haven, Mich.	–	–	−5.0	−5.2	−5.2	−4.9	−4.4	−3.7	−2.7	−1.5	–
Milwaukee, Wis.	–	–	–	–	–	−7.4	−6.9	−6.2	−5.4	−4.5	−3.6
Buffalo, N. Y.	0.2	0.2	0.4	0.8	1.3	2.0	2.8	3.7	4.5	5.3	6.0
Detroit, Mich.	−3.2	−3.1	−2.9	−2.5	−2.1	−1.6	−1.0	−0.4	0.1	0.6	0.9
Ypsilanti, Mich.	–	−4.1	−3.6	−3.0	−2.2	−1.4	−0.6	0.2	0.9	1.5	1.9
Erie, Pa.	−0.5	−0.5	−0.4	−0.1	0.4	0.9	1.6	2.3	3.0	3.6	4.2
Chicago, Ill.	–	–	−6.2	−6.3	−6.2	−6.0	−5.6	−5.1	−4.6	−4.0	−3.3
Michigan City, Ind.	–	–	–	−5.6	−5.4	−5.0	−4.6	−4.0	−3.5	−2.9	−2.3
Cleveland, Ohio	−1.9	−1.7	−1.5	−1.1	−0.6	−0.1	0.4	0.9	1.4	1.9	2.3
Omaha, Neb.	–	−12.5	−12.6	−12.6	−12.4	−12.0	−11.5	−10.9	−10.2	−9.5	−8.7
Beaver, Penn.	−1.1	−1.3	−1.3	−1.1	−0.8	−0.3	0.2	0.9	1.5	2.2	2.8
Pittsburg, Pa.	–	–	–	–	0.2	0.7	1.3	1.9	2.5	3.1	3.5
Denver, Colo.	–	–	–	–	–	–	−15.1	−14.9	−14.5	−14.1	–
Marietta, Ohio	–	−2.9	−2.8	−2.7	−2.3	−1.9	−1.3	−0.6	0.1	0.8	1.4
Athens, Ohio	−4.1	−4.1	−3.9	−3.6	−3.1	−2.6	−2.0	−1.4	−0.7	−0.1	0.4
Cincinnati, Ohio	−4.9	−5.0	−5.0	−4.8	−4.5	−4.1	−3.6	−3.0	−2.4	−1.8	−1.3
St. Louis, Mo.	–	–	–	−8.9	−8.6	−8.2	−7.7	−7.1	−6.4	−5.6	−4.9
Nashville, Tenn.	–	–	−6.7	−6.9	−6.9	−6.7	−6.3	−5.8	−5.1	−4.4	−3.6
Florence, Ala.	–	−6.5	−5.6	−6.5	−6.4	−6.1	−5.7	−5.3	−4.8	−4.3	−3.8
Mobile, Ala.	−5.8	−6.3	−6.7	−7.0	−7.1	−7.0	−6.7	−6.4	−5.8	−5.2	−4.6
Pensacola, Fla.	−6.8	−7.2	−7.5	−7.6	−7.4	−7.1	−6.6	−6.0	−5.3	−4.6	−3.8
New Orleans, La.	−7.1	−7.6	−8.0	−8.1	−8.2	−8.0	−7.7	−7.2	−6.6	−5.9	−5.2
San Antonio, Texas	–	–	−9.8	−10.1	−10.3	−10.2	−10.1	−9.7	−9.3	−8.7	−8.1
Key West, Fla.	–	–	−6.9	−6.5	−6.0	−5.5	−4.8	−4.2	−3.6	−3.0	−2.4
Havana, Cuba	−7.0	−6.9	−6.6	−6.3	−5.8	−5.3	−4.8	−4.2	−3.6	−3.0	−2.5
Kingston, Port Royal, Jamaica	−6.0	−5.8	−5.5	−5.1	−4.7	−4.3	−3.8	−3.3	−2.9	−2.5	−2.1
Barbadoes, Car. Isl.	−3.4	−3.0	−2.5	−2.0	−1.5	−0.9	−0.4	0.1	0.5	0.9	1.2
Panama, New Granada	−7.9	−7.8	−7.6	−7.3	−7.0	−6.7	−6.3	−5.9	−5.5	−5.0	−4.6

* This table gives the secular variation of the declination since the year 1800 for a series of stations in the Central States and adjacent countries. The minus sign indicates eastern declination. Reference same as Table 127.

TERRESTRIAL MAGNETISM.

Secular Variation of the Declination. — Western Stations.*

Station.	1800	1810	1820	1830	1840	1850	1860	1870	1880	1880	1900
	°	°	°	°	°	°	°	°	°	°	°
Acapulco, Mex.	7.6	8.1	8.5	8.7	8.9	8.9	8.7	8.5	8.1	7.6	7.1
Vera Cruz, Mex.	8.6	9.0	9.3	9.3	9.2	8.9	8.4	7.8	7.0	6.2	5.3
City of Mexico, Mex.	7.5	7.9	8.2	8.5	8.6	8.6	8.5	8.4	8.1	7.8	7.4
San Blas, Mex.	7.1	7.8	8.4	8.9	9.3	9.4	9.4	9.3	9.0	8.5	7.9
Cape San Lucas, Mex.	6.2	6.9	7.6	8.3	8.8	9.2	9.5	9.6	9.6	9.4	9.0
Magdalena Bay, L. Cal.	6.6	7.4	8.2	8.9	9.5	10.0	10.3	10.5	10.5	10.3	10.0
Ceros Island, Mex.	9.0	9.8	10.5	11.0	11.5	11.8	12.0	12.0	11.9	11.6	11.2
El Paso, Mex.	–	–	–	–	–	12.3	12.5	12.4	12.3	11.9	11.4
San Diego, Cal.	10.3	10.8	11.4	11.9	12.3	12.7	13.0	13.2	13.3	13.3	13.2
Santa Barbara, Cal.	11.6	12.3	12.9	13.4	13.9	14.3	14.6	14.8	14.8	14.8	14.6
Monterey, Cal.	12.3	12.9	13.4	13.9	14.4	14.9	15.3	16.6	15.9	16.0	16.1
San Francisco, Cal.	13.6	14.1	14.5	15.0	15.4	15.8	16.1	16.3	16.5	16.6	16.6
Cape Mendocino	15.1	15.6	16.0	16.5	16.9	17.2	17.4	17.6	17.7	17.7	17.6
Salt Lake City, Utah	–	–	–	–	–	16.0	16.4	16.6	16.6	16.3	15.7
Vancouver, Wash.	16.8	17.5	18.2	18.9	19.6	20.2	20.6	20.9	21.0	21.0	20.8
Walla Walla, Wash.	–	–	–	–	–	20.4	20.8	21.0	21.1	21.0	20.8
Cape Disappointment, Wash.	17.7	18.2	18.7	19.2	19.8	20.3	20.8	21.2	21.6	21.8	21.9
Seattle, Duwanish Bay, Wash.	–	–	–	–	–	21.3	21.8	22.1	22.3	22.2	22.1
Port Townsend, Wash.	18.1	18.8	19.6	20.3	20.9	21.4	21.7	21.8	21.8	21.5	21.1
Nee-ah Bay, Wash.	18.3	18.9	19.6	20.3	21.0	21.6	22.1	22.5	22.7	22.7	22.6
Nootka, Vancouver Island	19.6	20.1	20.7	21.3	22.0	22.5	23.0	23.5	23.8	23.9	24.0
Captain's and Iliuliuk Harbors, Unilaska Island	19.3	19.6	19.7	19.8	19.7	19.7	19.5	19.3	18.9	18.6	18.2
Sitka, Alaska	26.4	27.1	27.8	28.3	28.7	29.0	29.1	29.0	28.8	28.4	27.9
St. Paul, Kadiak Island	25.5	26.4	27.0	27.3	27.4	27.1	26.6	25.9	25.0	23.9	22.7
Port Mulgrave, Yakutat Bay, Alaska	27.8	29.2	30.4	31.2	31.7	31.8	31.4	30.7	29.7	28.4	26.8
Port Etches, Alaska	27.8	29.3	30.4	31.2	31.6	31.5	31.0	30.1	28.8	27.3	25.5
Port Clarence, Alaska	–	–	26.6	27.0	26.9	26.4	25.6	24.4	22.9	21.2	19.5
Chamisso Island, Kotzebue Sound	–	–	31.1	31.3	31.1	30.5	29.6	28.3	26.8	25.2	23.5
Petropavlovsk, Kamchatka, Siberia	5.7	5.2	4.7	4.1	3.4	2.7	2.1	1.5	1.0	0.7	0.5

* This table gives the secular variation of the declination since the year 1800 for a series of stations in the Western States and adjacent countries. The declinations are all east of north. Reference same as Table 127.

TERRESTRIAL MAGNETISM.

Agonic Lines.*

The line of no declination is moving westward in the United States, and east declination is decreasing west of, while west declination is increasing east of the agonic line.

Lat. N.	Longitudes of the agonic line for the years —			
	1800	1850	1875	1890
°	°	°	°	°
25	–	–	–	75.5
30	–	–	–	78.6
35	–	76.7	79.0	79.9
6	75.2	77.3	79.7	80.5
7	76.3	77.7	80.6	82.2
8	76.7	78.3	81.3	82.6
9	76.9	78.7	81.6	82.2
40	77.0	79.3	81.6	82.7
1	77.9	80.4	81.8	82.8
2	79.1	81.0	82.6	83.7
3	79.4	81.2	83.1	84.3
4	79.8	–	83.3	84.9
45	–	–	83.6	85.2
6	–	–	84.2	84.8
7	–	–	85.1	85.4
8	–	–	86.0	85.9
9	–	–	86.5	86.3

* Reference same as Table 127.

TERRESTRIAL MAGNETISM.

Date of Maximum East Declination.*

This table gives the date of maximum east declination for a number of stations, beginning at the northeast of the United States and extending down the Atlantic coast to New York and west to the Pacific.

Station.	Date.
Halifax,† N. S.	1714
Eastport, Me.	1753
Bangor, Me.	1774
Portland, Me.	1779
Boston, Mass.	1780
New Haven, Conn.	1800
New York, N. Y.	1784
Jamesburg, N. J.	1802
Philadelphia, Pa.	1802
Pittsburg, Pa.	1808
Cincinnati, Ohio	1814
Florence, Ala.	1821
St. Louis, Mo.	1822
Nashville, Tenn.	1834
Chicago, Ill.	1831
Denver, Colo.	1839
Salt Lake, Utah	1873
Vancouver, Wash.	1883
Cape Mendocino, Cal.	1886
San Francisco, Cal.	1893

* Reference same as Table 127.
† The opposite phase of maximum west declination is now located at Halifax.

PRESSURE OF COLUMNS OF MERCURY AND WATER.

British and metric measures. Correct at 0° C. for mercury and at 4° C. for water.

Metric Measure.			British Measure.		
Cms. of Hg.	Pressure in grammes per sq. cm.	Pressure in pounds per sq. inch.	Inches of Hg.	Pressure in grammes per sq. cm.	Pressure in pounds per sq. inch.
1	13.5956	0.193376	1	34.533	0.491174
2	27.1912	0.386752	2	69.066	0.982348
3	40.7868	0.580128	3	103.598	1.473522
4	54.3824	0.773504	4	138.131	1.964696
5	67.9780	0.966880	5	172.664	2.455870
6	81.5736	1.160256	6	207.197	2.947044
7	95.1692	1.353632	7	241.730	3.438218
8	108.7648	1.547008	8	276.262	3.929392
9	122.3604	1.740384	9	310.795	4.420566
10	135.9560	1.933760	10	345.328	4.911740
Cms. of H_2O.	Pressure in grammes per sq. cm.	Pressure in pounds per sq. inch.	Inches of H_2O.	Pressure in grammes per sq. cm.	Pressure in pounds per sq. inch.
1	1	0.0142234	1	2.54	0.036227
2	2	0.0284468	2	5.08	0.072255
3	3	0.0426702	3	7.62	0.108382
4	4	0.0568936	4	10.16	0.144510
5	5	0.0711170	5	12.70	0.180637
6	6	0.0853404	6	15.24	0.216764
7	7	0.0995658	7	17.78	0.252892
8	8	0.1137872	8	20.32	0.289019
9	9	0.1280106	9	22.86	0.325147
10	10	0.1422340	10	25.40	0.361274

TABLE 133.

REDUCTION OF BAROMETRIC HEIGHT TO STANDARD TEMPERATURE.*

Corrections for brass scale and English measure.	
Height of barometer in inches.	α in inches for temp. F.
15.0	0.00135
16.0	.00145
17.0	.00154
17.5	.00158
18.0	.00163
18.5	.00167
19.0	.00172
19.5	.00176
20.0	0.00181
20.5	.00185
21.0	.00190
21.5	.00194
22.0	.00199
22.5	.00203
23.0	.00208
23.5	.00212
24.0	0.00217
24.5	.00221
25.0	.00226
25.5	.00231
26.0	.00236
26.5	.00240
27.0	.00245
27.5	.00249
28.0	0.00254
28.5	.00258
29.0	.00263
29.2	.00265
29.4	.00267
29.6	.00268
29.8	.00270
30.0	.00272
30.2	0.00274
30.4	.00276
30.6	.00277
30.8	.00279
31.0	.00281
31.2	.00283
31.4	.00285
31.6	.00287

Corrections for brass scale and metric measure.	
Height of barometer in mm.	α in mm. for temp. C.
400	0.0651
410	.0668
420	.0684
430	.0700
440	.0716
450	.0732
460	.0749
470	.0765
480	.0781
490	.0797
500	0.0813
510	.0830
520	.0846
530	.0862
540	.0878
550	.0894
560	.0911
570	.0927
580	.0943
590	.0959
600	0.0975
610	.0992
620	.1008
630	.1024
640	.1040
650	.1056
660	.1073
670	.1089
680	.1105
690	.1121
700	0.1137
710	.1154
720	.1170
730	.1186
740	.1202
750	.1218
760	.1235
770	.1251
780	.1267
790	.1283
800	.1299

Corrections for glass scale and metric measure.	
Height of barometer in mm.	α in mm. for temp. C.
50	0.0086
100	.0172
150	.0258
200	.0345
250	.0431
300	.0517
350	.0603
400	0.0689
450	.0775
500	.0861
520	.0898
540	.0934
560	.0971
580	.1007
600	0.1034
610	.1051
620	.1068
630	.1085
640	.1103
650	.1120
660	.1137
670	0.1154
680	.1172
690	.1189
700	.1206
710	.1223
720	.1240
730	.1258
740	0.1275
750	.1292
760	.1309
770	.1327
780	.1344
790	.1361
800	.1378
850	0.1464
900	.1551
950	.1639
1000	.1723

* The height of the barometer is affected by the relative thermal expansion of the mercury and the glass, in the case of instruments graduated on the glass tube, and by the relative expansion of the mercury and the metallic inclosing case, usually of brass, in the case of instruments graduated on the brass case. This relative expansion is practically proportional to the first power of the temperature. The above tables of values of the coefficient of relative expansion will be found to give corrections almost identical with those given in the International Meteorological Tables. The numbers tabulated under α are the values of α in the equation $H_t = H_t' - \alpha(t' - t)$ where H_t is the height at the standard temperature, H_t' the observed height at the temperature t', and $\alpha(t' - t)$ the correction for temperature. The standard temperature is 0° C. for the metric system and 28°.5 F. for the English system. The English barometer is correct for the temperature of melting ice at a temperature of approximately 28°.5 F., because of the fact that the brass scale is graduated so as to be standard at 62° F., while mercury has the standard density at 32° F.

EXAMPLE.—A barometer having a brass scale gave $H = 765$ mm. at 25° C.; required, the corresponding reading at 0° C. Here the value of α is the mean of .1235 and .1251, or .1243; ∴ $\alpha(t' - t) = .1243 \times 25 = 3.11$. Hence $H_0 = 765 - 3.11 = 761.89$.

N. B.—Although α is here given to three and sometimes to four significant figures, it is seldom worth while to use more than the nearest two-figure number. In fact, all barometers have not the same values for α, and when great accuracy is wanted the proper coefficients have to be determined by experiment.

CORRECTION OF BAROMETER TO STANDARD GRAVITY.

Height above sea level in metres.	Observed height of barometer in millimetres.									
	400	450	500	550	600	650	700	750	800	
100							.014	.015	.016	
200							.028	.030	.032	
300							.041	.044	.047	
400							.055	.059	.063	
500						.064	.068	.073	.078	
600						.077	.082	.088		
700						.090	.096	.102		
800						.103	.109	.117		
900						.115	.123	.131		
1000				.108	.118	.128	.137	.146		
1100				.118	.130	.141	.150			
1200				.129	.142	.154	.164			
1300				.140	.153	.166	.178			
1400				.151	.165	.179	.191			
1500			.147	.162	.176	.191	.205			
1600			.157	.172	.188	.204				
1700			.167	.183	.200	.217				
1800			.177	.194	.212	.230			1.245	15000
1900			.187	.204	.224	.242			1.203	14500
2000		.176	.196	.215	.235	.255		1.340	1.162	14000
2100		.185	.206	.226	.247			1.292	1.120	13500
2200		.194	.216	.237	.259			1.244	1.088	13000
2300		.203	.226	.248	.271		1.345	1.196	1.046	12500
2400		.212	.236	.259	.283		1.291	1.149	1.004	12000
2500	.195	.220	.245	.270	.295		1.237	1.101	.962	11500
2600	.203	.229	.255			1.315	1.184	1.053	.920	11000
2700	.211	.238	.265			1.255	1.130	1.005	.879	10500
2800	.219	.247	.275			1.196	1.076	.957	.837	10000
2900	.227	.256	.285		1.050	1.136	1.022	.909	.795	9500
3000	.235	.265	.294		.984	1.076	.969	.861	.753	9000
3100	.243	.274			.918	1.016	.915	.813		8500
3200	.251	.283			.853	.957	.861	.765		8000
3300	.259	.292		1.077	.787	.897	.807			7500
3400	.267	.201		1.005	.721	.837	.753			7000
3500	.275	.309		.934	.655	.777	.700			6500
3600	.283			.862	.789	.718				6000
3700	.291			.790	.724	.658				5500
3800	.299		.779	.718	.658	.598				5000
3900	.307		.701	.646	.592					4500
4000	.314		.623	.574	.526					4000
			.545	.503	.461					3500
		.503	.467	.431	.395					3000
		.419	.389	.359						2500
	.359	.335	.311	.287						2000
	.269	.251	.233	.215						1500
.192	.179	.167	.155							1000
.096	.090	.084	.078							500
32	30	28	26	24	22	20	18	16	14	Height above sea level in feet.
Observed height of barometer in inches.										

Correction in millimetres for elevation above sea level in first column and height of barometer in top line.

Corrections in hundredths of an inch for elevation above sea level in last column and height of barometer in bottom line.

REDUCTION OF BAROMETER TO STANDARD GRAVITY.*

Reduction to Latitude 45°. — English Scale.

N. B. From latitude 0° to 44° the correction is to be subtracted.
From latitude 90° to 46° the correction is to be added.

Latitude.		Height of the barometer in inches.											
		19	20	21	22	23	24	25	26	27	28	29	30
		Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
0°	90°	0.051	0.053	0.056	0.059	0.061	0.064	0.067	0.069	0.072	0.074	0.077	0.080
5	85	0.050	0.052	0.055	0.058	0.060	0.063	0.066	0.068	0.071	0.073	0.076	0.079
6	84	.049	.052	.055	.057	.060	.062	.065	.068	.070	.073	.076	.078
7	83	.049	.052	.054	.057	.059	.062	.065	.067	.070	.072	.075	.077
8	82	.049	.051	.054	.056	.059	.061	.064	.067	.069	.072	.074	.077
9	81	.048	.051	.053	.056	.058	.061	.063	.066	.068	.071	.073	.076
10	80	0.048	0.050	0.053	0.055	0.058	0.060	0.063	0.065	0.068	0.070	0.073	0.075
11	79	.047	.049	.052	.054	.057	.059	.062	.064	.067	.069	.072	.074
12	78	.046	.049	.051	.054	.056	.058	.061	.063	.066	.068	.071	.073
13	77	.045	.048	.050	.053	.055	.057	.060	.062	.065	.067	.069	.072
14	76	.045	.047	.049	.052	.054	.056	.059	.061	.063	.066	.068	.071
15	75	0.044	0.046	0.048	0.051	0.053	0.055	0.058	0.060	0.062	0.065	0.067	0.069
16	74	.043	.045	.047	.050	.052	.054	.056	.059	.061	.063	.065	.068
17	73	.042	.044	.046	.049	.051	.053	.055	.057	.060	.062	.064	.066
18	72	.041	.043	.045	.047	.050	.052	.054	.056	.058	.060	.062	.065
19	71	.040	.042	.044	.046	.048	.050	.052	.055	.057	.059	.061	.063
20	70	0.039	0.041	0.043	0.045	0.047	0.049	0.051	0.053	0.055	0.057	0.059	0.061
21	69	.038	.040	.042	.044	.045	.047	.049	.051	.053	.055	.057	.059
22	68	.036	.038	.040	.042	.044	.046	.048	.050	.052	.054	.056	.057
23	67	.035	.037	.039	.041	.043	.044	.046	.048	.050	.052	.054	.055
24	66	.034	.036	.037	.039	.041	.043	.045	.046	.048	.050	.052	.053
25	65	0.033	0.034	0.036	0.038	0.039	0.041	0.043	0.044	0.046	0.048	0.050	0.051
26	64	.031	.033	.034	.036	.038	.039	.041	.043	.044	.046	.048	.049
27	63	.030	.031	.033	.034	.036	.038	.039	.041	.042	.044	.045	.047
28	62	.028	.030	.031	.033	.034	.036	.037	.039	.040	.042	.043	.045
29	61	.027	,028	.030	.031	.032	.034	.035	.037	.038	.039	.041	.042
30	60	0.025	0.027	0.028	0.029	0.031	0.032	0.033	0.035	0.036	0.037	0.039	0.040
31	59	.024	.025	.026	.027	.029	.030	.031	.032	.034	.035	.036	.037
32	58	.022	.023	.025	.026	.027	.028	.029	.030	.032	.033	.034	.035
33	57	.021	.022	.023	.024	.025	.026	.027	.028	.029	.030	.031	.032
34	56	.019	.020	.021	.022	.023	.024	.025	.026	.027	.028	.029	.030
35	55	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024	0.025	0.025	0.026	0.027
36	54	.016	.016	.017	.018	.019	.020	.021	.021	.022	.023	.024	.025
37	53	.014	.015	.015	.016	.017	.018	.018	.019	.020	.021	.021	.022
38	52	.012	.013	.014	.014	.015	.015	.016	.017	.017	.018	.019	.019
39	51	.011	.011	.012	.012	.013	.013	.014	.014	.015	.015	.016	.017
40	50	0.009	0.009	0.010	0.010	0.011	0.011	0.012	0.012	0.012	0.013	0.013	0.014
41	49	.007	.007	.008	.008	.009	.009	.009	.010	.010	.010	.011	.011
42	48	.005	.006	.006	.006	.006	.007	.007	.007	.008	.008	.008	.008
43	47	.004	.004	.004	.004	.004	.004	.005	.005	.005	.005	.005	.006
44	46	.002	.002	.002	.002	.002	.002	.002	.002	.003	.003	.003	.003

* "Smithsonian Meteorological Tables," p. 58.

REDUCTION OF BAROMETER TO STANDARD GRAVITY.*

Reduction to Latitude 45°. — Metric Scale.

N. B. — From latitude 0° to 44° the correction is to be subtracted.
From latitude 90° to 46° the correction is to be added.

Latitude.		Height of the barometer in millimetres.											
		520	560	600	620	640	660	680	700	720	740	760	780
		mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	**90°**	1.38	1.49	1.60	1.65	1.70	1.76	1.81	1.86	1.92	1.97	2.02	2.08
5	**85**	1.36	1.47	1.57	1.63	1.68	1.73	1.81	1.84	1.89	1.94	1.99	2.04
6	84	1.35	1.46	1.56	1.61	1.67	1.72	1.78	1.82	1.87	1.93	1.98	2.03
7	83	1.34	1.45	1.55	1.60	1.65	1.70	1.77	1.81	1.86	1.91	1.96	2.01
8	82	1.33	1.43	1.54	1.59	1.64	1.69	1.76	1.79	1.84	1.89	1.94	2.00
9	81	1.32	1.42	1.52	1.57	1.62	1.67	1.74	1.77	1.82	1.87	1.92	1.97
10	**80**	1.30	1.40	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95
11	79	1.28	1.38	1.48	1.53	1.58	1.63	1.68	1.73	1.78	1.83	1.88	1.93
12	78	1.26	1.36	1.46	1.51	1.56	1.60	1.65	1.70	1.75	1.80	1.85	1.90
13	77	1.24	1.34	1.44	1.48	1.53	1.58	1.63	1.67	1.72	1.77	1.82	1.87
14	76	1.22	1.32	1.41	1.46	1.50	1.55	1.60	1.65	1.69	1.74	1.79	1.83
15	**75**	1.20	1.29	1.38	1.43	1.48	1.52	1.57	1.61	1.66	1.71	1.75	1.80
16	74	1.17	1.26	1.35	1.40	1.44	1.49	1.54	1.58	1.63	1.67	1.72	1.76
17	73	1.15	1.24	1.32	1.37	1.41	1.45	1.50	1.54	1.59	1.63	1.68	1.72
18	72	1.12	1.21	1.29	1.34	1.38	1.42	1.46	1.51	1.55	1.59	1.64	1.68
19	71	1.09	1.17	1.26	1.30	1.34	1.38	1.43	1.47	1.51	1.55	1.59	1.64
20	**70**	1.06	1.14	1.22	1.26	1.31	1.35	1.39	1.43	1.47	1.51	1.55	1.59
21	69	1.03	1.11	1.19	1.23	1.27	1.31	1.35	1.38	1.42	1.46	1.50	1.54
22	68	1.00	1.07	1.15	1.19	1.23	1.26	1.30	1.34	1.38	1.42	1.46	1.49
23	67	0.96	1.04	1.11	1.15	1.18	1.22	1.26	1.29	1.33	1.37	1.41	1.44
24	66	.93	1.00	1.07	1.10	1.14	1.18	1.21	1.25	1.28	1.32	1.35	1.39
25	**65**	0.89	0.96	1.03	1.06	1.10	1.13	1.16	1.20	1.23	1.27	1.30	1.33
26	64	.85	.92	0.98	1.02	1.05	1.08	1.11	1.15	1.18	1.21	1.25	1.28
27	63	.81	.88	.94	0.97	1.00	1.03	1.06	1.10	1.13	1.16	1.19	1.22
28	62	.77	.83	.89	.92	0.95	0.98	1.01	1.04	1.07	1.10	1.13	1.16
29	61	.73	.79	.85	.87	.90	.93	0.96	0.99	1.02	1.04	1.07	1.10
30	**60**	0.69	0.75	0.80	0.83	0.85	0.88	0.91	0.94	0.96	0.98	1.01	1.04
31	59	.65	.70	.75	.77	.80	.82	.85	.87	.90	.92	0.95	0.97
32	58	.61	.65	.70	.72	.75	.77	.79	.82	.84	.86	.89	.91
33	57	.56	.61	.65	.67	.69	.71	.74	.76	.78	.80	.82	.84
34	56	.52	.56	.60	.62	.64	.66	.68	.70	.72	.74	.76	.78
35	**55**	0.47	0.51	0.55	0.56	0.58	0.60	0.62	0.64	0.66	0.67	0.69	0.71
36	54	.43	.46	.49	.51	.53	.54	.56	.58	.59	.61	.63	.64
37	53	.38	.41	.44	.45	.47	.48	.50	.51	.53	.54	.56	.57
38	52	.33	.36	.39	.40	.41	.43	.44	.45	.46	.48	.49	.50
39	51	.29	.31	.33	.34	.35	.37	.38	.39	.40	.41	.42	.43
40	**50**	0.24	0.26	0.28	0.29	0.30	0.31	0.31	0.32	0.33	0.34	0.35	0.36
41	49	.19	.21	.22	.23	.24	.24	.25	.26	.27	.27	.28	.29
42	48	.14	.16	.17	.17	.18	.18	.19	.19	.20	.21	.21	.22
43	47	.10	.10	.11	.12	.12	.12	.13	.13	.13	.14	.14	.14
44	46	.05	.05	.06	.06	.06	.06	.06	.07	.07	.07	.07	.07

* "Smithsonian Meteorological Tables," p. 59.

CORRECTION OF THE BAROMETER FOR CAPILLARITY.*

1. Metric Measure.

Diameter of tube in mm.	Height of Meniscus in Millimetres.							
	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8
	Correction to be added in millimetres.							
4	0.83	1.22	1.54	1.98	2.37	–	–	–
5	.47	0.65	0.86	1.19	1.45	1.80	–	–
6	.27	.41	.56	0.78	0.98	1.21	1.43	–
7	.18	.28	.40	.53	.67	0.82	0.97	1.13
8	–	.20	.29	.38	.46	.56	.65	0.77
9	–	.15	.21	.28	.33	.40	.46	.52
10	–	–	.15	.20	.25	.29	.33	.37
11	–	–	.10	.14	.18	.21	.24	.27
12	–	–	.07	.10	.13	.15	.18	.19
13	–	–	.04	.07	.10	.12	.13	.14

2. British Measure.

Diameter of tube in inches.	Height of Meniscus in Inches.							
	.01	.02	.03	.04	.05	.06	.07	.08
	Correction to be added in hundredths of an inch.							
.15	2.36	4.70	6.86	9.23	11.56	–	–	–
.20	1.10	2.20	3.28	4.54	5.94	7.85	–	–
.25	0.55	1.20	1.92	2.76	3.68	4.72	5.88	–
.30	.36	0.79	1.26	1.77	2.30	2.88	3.48	4.20
.35	–	.51	0.82	1.15	1.49	1.85	2.24	2.65
.40	–	.40	.61	0.81	1.02	1.22	1.42	1.62
.45	–	–	.32	.51	0.68	0.83	0.96	1.15
.50	–	–	.20	.35	.47	.56	.64	0.71
.55	–	–	.08	.20	.31	.40	.47	.52

* The first table is from Kohlrausch (Experimental Physics), and is based on the experiments of Mendelejeff and Gutkowski (Jour. de Phys. Chem. Geo. Petersburg, 1877, or Wied. Beib. 1867). The second table has been calculated from the same data by conversion into inches and graphic interpolation.

A number of tables, mostly based on theoretical formulæ and the capillary constants of mercury in glass tubes in air and vacuum, were given in the fourth edition of Guyot's Tables, and may be there referred to. They are not repeated here, as the above is probably more accurate, and historical matter is excluded for convenience in the use of the book.

ABSORPTION OF GASES BY LIQUIDS.*

Temperature Centigrade. t	Absorption Coefficients, a_t, for Gases in Water.						
	Carbon dioxide. CO_2	Carbon monoxide. CO	Hydrogen. H	Nitrogen. N	Nitric oxide. NO	Nitrous oxide. N_2O	Oxygen. O
0	1.797	0.0354	0.02110	0.02399	0.0738	1.305	0.04925
5	1.450	.0315	.02022	.02134	.0646	1.095	.04335
10	1.185	.0282	.01944	.01918	.0571	0.920	.03852
15	1.002	.0254	.01875	.01742	.0515	0.778	.03456
20	0.901	.0232	.01809	.01599	.0471	0.670	.03137
25	0.772	.0214	.01745	.01481	.0432	–	.02874
30	–	.0200	.01690	.01370	–	–	.02646
40	0.506	.0177	.01644	.01195	–	–	.02316
50	–	.0161	.01608	.01074	–	–	.02080
100	0.244	–	.01600	.01011	–	–	.01690

Temperature Centigrade. t	Air.	Ammonia. NH_3	Chlorine. Cl	Ethylene. C_2H_4	Methane. CH_4	Hydrogen sulphide. H_2S	Sulphur dioxide. SO_2
0	0.02471	1174.6	3.036	0.2563	0.05473	4.371	79.79
5	.02179	971.5	2.808	.2153	.04889	3.965	67.48
10	.01953	840.2	2.585	.1837	.04367	3.586	56.65
15	.01795	756.0	2.388	.1615	.03903	3.233	47.28
20	.01704	683.1	2.156	.1488	.03499	2.905	39.37
25	–	610.8	1.950	–	.02542	2.604	32.79

Temperature Centigrade. t	Absorption Coefficients, a_t, for Gases in Alcohol, C_2H_5OH.							
	Carbon dioxide. CO_2	Ethylene. C_2H_4	Methane. CH_4	Hydrogen. H	Nitrogen. N	Nitric oxide. NO	Nitrous oxide. N_2O	Hydrogen sulphide. H_2S	Sulphur dioxide. SO_2
0	4.329	3.595	0.5226	0.0692	0.1263	0.3161	4.190	17.89	328.6
5	3.891	3.323	.5086	.0685	.1241	.2998	3.838	14.78	251.7
10	3.514	3.086	.4953	.0679	.1228	.2861	3.525	11.99	190.3
15	3.199	2.882	.4828	.0673	.1214	.2748	3.215	9.54	144.5
20	2.946	2.713	.4710	.0667	.1204	.2659	3.015	7.41	114.5
25	2.756	2.578	.4598	.0662	.1196	.2595	2.819	5.62	99.8

* This table contains the volumes of different gases, supposed measured at 0° C. and 76 centimetres' pressure, which unit volume of the liquid named will absorb at atmospheric pressure and the temperature stated in the first column. The numbers tabulated are commonly called the absorption coefficients for the gases in water, or in alcohol, at the temperature t and under one atmosphere of pressure. The table has been compiled from data published by Bohr & Bock, Bunsen, Carius, Dittmar, Hamberg, Henrick, Pagliano & Emo, Raoult, Schönfeld, Setschenow, and Winkler. The numbers are in many cases averages from several of these authorities.

NOTE. — The effect of increase of pressure is generally to increase the absorption coefficient. The following is approximately the magnitude of the effect in the case of ammonia in alcohol at a temperature of 23° C.:

P =	45 cms.	50 cms.	55 cms.	60 cms.	65 cms.
a_{23} =	69	74	79	84	88

According to Setschenow the effect of varying the pressure from 45 to 85 centimetres in the case of carbonic acid in water is very small.

VAPOR PRESSURES.

The vapor pressures here tabulated have been taken, with one exception, from Regnault's results. The vapor pressure of Pictet's fluid is given on his own authority. The pressures are in centimetres of mercury.

Temperature Cent.	Acetone. C_3H_6O	Benzol. C_6H_6	Carbon bisulphide. CS_2	Carbon tetrachloride. CCl_4	Chloroform. $CHCl_3$	Ethyl alcohol. C_2H_6O	Ethyl ether. $C_4H_{10}O$	Ethyl bromide. C_2H_5Br	Methyl alcohol. CH_4O	Turpentine. $C_{10}H_6$
—25°	-	-	-	-	-	-	-	4.41	.41	-
—20	-	.58	4.73	.98	-	.33	6.89	5.92	.63	-
—15	-	.88	6.16	1.35	-	.51	8.93	7.81	.93	-
—10	-	1.29	7.94	1.85	-	.65	11.47	10.15	1.35	-
—5	-	1.83	10.13	2.48	-	.91	14.61	13.06	1.92	-
0	-	2.53	12.79	3.29	-	1.27	18.44	16.56	2.68	.21
5	-	3.42	16.00	4.32	-	1.76	23.09	20.72	3.69	-
10	-	4.52	19.85	5.60	-	2.42	28.68	25.74	5.01	.29
15	-	5.89	24.41	7.17	-	3.30	35.36	31.69	6.71	-
20	17.96	7.56	29.80	9.10	16.05	4.45	43.28	38.70	8.87	.44
25	22.63	9.59	36.11	11.43	20.02	5.94	52.59	46.91	11.60	-
30	28.10	12.02	43.46	14.23	24.75	7.85	63.48	56.45	15.00	.69
35	34.52	14.93	51.97	17.55	30.35	10.29	76.12	67.49	19.20	-
40	42.01	18.36	61.75	21.48	36.93	13.37	90.70	80.19	24.35	1.08
45	50.75	22.41	72.95	26.08	44.60	17.22	107.42	94.73	30.61	-
50	62.29	27.14	85.71	31.44	53.50	21.99	126.48	111.28	38.17	1.70
55	72.59	32.64	100.16	37.63	63.77	27.86	148.11	130.03	47.22	-
60	86.05	39.01	116.45	44.74	75.54	35.02	172.50	151.19	57.99	2.65
65	101.43	46.34	134.75	52.87	88.97	43.69	199.89	174.95	70.73	-
70	118.94	54.74	155.21	62.11	104.21	54.11	230.49	201.51	85.71	4.06
75	138.76	64.32	177.99	72.57	121.42	66.55	264.54	231.07	103.21	-
80	161.10	75.19	203.25	84.33	140.76	81.29	302.28	263.86	123.85	6.13
85	186.18	87.46	231.17	97.51	162.41	98.64	343.95	300.06	147.09	-
90	214.17	101.27	261.91	112.23	186.52	118.93	389.83	339.89	174.17	9.06
95	245.28	116.75	296.63	128.69	213.28	142.51	440.18	383.55	205.17	-
100	279.73	134.01	332.51	146.71	242.85	169.75	495.33	431.23	240.51	13.11
105	317.70	153.18	372.72	166.72	275.40	201.04	555.62	483.12	280.63	-
110	359.40	174.14	416.41	188.74	311.10	236.76	621.46	539.40	325.96	18.60
115	405.00	197.82	463.74	212.91	350.10	277.34	693.33	600.24	376.98	-
120	454.69	223.54	514.88	239.37	392.57	323.17	771.92	665.80	434.18	25.70
125	508.62	251.71	569.97	268.24	438.66	374.69	-	736.22	498.05	-
130	566.97	282.43	629.16	299.69	488.51	432.30	-	811.65	569.13	34.90
135	629.87	315.85	692.59	333.86	542.25	496.42	-	892.19	647.93	-
140	697.44	352.07	760.40	370.90	600.02	567.46	-	977.96	733.71	46.40
145	-	391.21	832.69	411.00	661.92	645.80	-	-	830.89	-
150	-	433.37	909.59	454.31	728.06	731.84	-	-	936.13	60.50
155	-	478.65	-	501.02	798.53	825.92	-	-	-	68.60
160	-	527.14	-	551.31	873.42	-	-	-	-	77.50
165	-	568.30	-	605.38	952.78	-	-	-	-	-
170	-	634.07	-	663.44	-	-	-	-	-	-

VAPOR PRESSURES.

Temperature, Centigrade.	Ammonia. NH_3	Carbon dioxide. CO_2	Ethyl chloride. C_2H_5Cl	Ethyl iodide. C_2H_5I	Methyl chloride. CH_3Cl	Methylic ether. C_2H_6O	Nitrous oxide. N_2O	Pictet's fluid. $64SO_2+44CO_2$ by weight	Sulphur dioxide. SO_2	Hydrogen sulphide. H_2S
—30°	86.61	-	11.02	-	57.90	57.65	-	58.52	28.75	-
—25	110.43	1300.70	14.50	-	71.78	71.61	1569.49	67.64	37.38	374.93
—20	139.21	1514.24	18.75	-	88.32	88.20	1758.66	74.48	47.95	443.85
—15	173.65	1758.25	23.96	-	107.92	107.77	1968.43	89.68	60.79	519.65
—10	214.46	2034.02	30.21	-	130.96	130.66	2200.80	101.84	76.25	608.46
—5	264.42	2344.13	37.67	-	157.87	157.25	2457.92	121.60	94.69	706.60
0	318.33	2690.66	46.52	4.19	189.10	187.90	2742.10	139.08	116.51	820.63
5	383.03	3075.38	56.93	5.41	225.11	222.90	3055.86	167.20	142.11	949.08
10	457.40	3499.86	61.11	6.92	266.38	262.90	3401.91	193.80	171.95	1089.63
15	543.34	3964.69	83.26	8.76	313.41	307.98	3783.17	226.48	206.49	1244.79
20	638.78	4471.66	99.62	11.00	366.69	358.60	4202.79	258.40	246.20	1415.15
25	747.70	5020.73	118.42	13.69	426.74	415.10	4664.14	297.92	291.60	1601.24
30	870.10	5611.90	139.90	16.91	494.05	477.80	5170.85	338.20	343.18	1803.53
35	1007.02	6244.73	164.32	20.71	569.11	-	6335.98	383.80	401.48	2002.43
40	1159.53	6918.44	191.96	25.17	-	-	-	434.72	467.02	2258.25
45	1328.73	7631.46	223.07	30.38	-	-	-	478.80	540.35	2495.43
50	1515.83	-	257.94	36.40	-	-	-	521.36	622.00	2781.48
55	1721.98	-	266.84	43.32	-	-	-	-	712.50	3069.07
60	1948.21	-	340.05	51.22	-	-	-	-	812.38	3374.02
65	2196.51	-	387.85	-	-	-	-	-	922.14	3696.15
70	2467.55	-	440.50	-	-	-	-	-	-	4035.32
75	2763.00	-	498.27	-	-	-	-	-	-	-
80	3084.31	-	561.41	-	-	-	-	-	-	-
85	3433.09	-	630.16	-	-	-	-	-	-	-
90	3810.92	-	704.75	-	-	-	-	-	-	-
95	4219.57	-	785.39	-	-	-	-	-	-	-
100	4660.82	-	872.28	-	-	-	-	-	-	-

CAPILLARITY.—SURFACE TENSION OF LIQUIDS.*

TABLE 140.—Water and Alcohol in Contact with Air.

Temp. C.	Surface tension in dynes per centimetre.		Temp. C.	Surface tension in dynes per centimetre.		Temp. C.	Surface tension in dynes per centimetre.
	Water.	Ethyl alcohol.		Water.	Ethyl alcohol.		Water.
0°	75.6	23.5	40°	70.0	20.0	80°	64.3
5	74.9	23.1	45	69.3	19.5	85	63.6
10	74.2	22.6	50	68.6	19.1	90	62.9
15	73.5	22.2	55	67.8	18.6	95	62.2
20	72.8	21.7	60	67.1	18.2	100	61.5
25	72.1	21.3	65	66.4	17.8	–	–
30	71.4	20.8	70	65.7	17.3	–	–
35	70.7	20.4	75	65.0	16.9	–	–

TABLE 141.—Miscellaneous Liquids in Contact with Air.

Liquid.	Temp. C.°	Surface tension in dynes per centimetre.	Authority.
Aceton	14.0	25.6	Average of various.
Acetic acid . . .	17.0	30.2	"
Amyl alcohol . .	15.0	24.8	"
Benzene	15.0	28.8	"
Butyric acid . .	15.0	28.7	"
Carbon disulphide	20.0	30.5	Quincke.
Chloroform . . .	20.0	28.3	Average of various.
Ether	20.0	18.4	"
Glycerine . . .	17.0	63.14	Hall.
Hexane	0.0	21.2	Schiff.
"	68.0	14.2	"
Mercury	20.0	470.0	Average of various.
Methyl alcohol .	15.0	24.7	"
Olive oil	20.0	34.7	"
Petroleum . . .	20.0	25.9	Magie.
Propyl alcohol . .	5.8	25.9	Schiff.
" " . .	97.1	18.0	"
Toluol	15.0	29.1	"
"	109.8	18.9	"
Turpentine . . .	21.0	28.5	Average of various.

TABLE 142.—Solutions of Salts in Water.†

Salt in solution.	Density.	Temp. C.°	Tension in dynes per cm.
$BaCl_2$	1.2820	15–16	81.8
"	1.0497	15–16	77.5
$CaCl_2$	1.3511	19	95.0
"	1.2773	19	90.2
HCl	1.1190	20	73.6
"	1.0887	20	74.5
"	1.0242	20	75.3
KCl	1.1699	15–16	82.8
"	1.1011	15–16	80.1
"	1.0463	15–16	78.2
$MgCl_2$	1.2338	15–16	90.1
"	1.1694	15–16	85.2
"	1.0362	15–16	78.0
NaCl	1.1932	20	85.8
"	1.1074	20	80.5
"	1.0360	20	77.6
NH_4Cl	1.0758	16	84.3
"	1.0535	16	81.7
"	1.0281	16	78.8
$SrCl_2$	1.3114	15–16	85.6
"	1.1204	15–16	79.4
"	1.0567	15–16	77.8
K_2CO_3	1.3575	15–16	90.9
"	1.1576	15–16	81.8
"	1.0400	15–16	77.5
Na_2CO_3	1.1329	14–15	79.3
"	1.0605	14–15	77.8
"	1.0283	14–15	77.2
KNO_3	1.1263	14	78.9
"	1.0466	14	77.6
$NaNO_3$	1.3022	12	83.5
"	1.1311	12	80.0
$CuSO_4$	1.1775	15–16	78.6
"	1.0276	15–16	77.0
H_2SO_4	1.8278	15	63.0?
"	1.4453	15	79.7
"	1.2636	15	79.7
K_2SO_4	1.0744	15–16	78.0
"	1.0360	15–16	77.4
$MgSO_4$	1.2744	15–16	83.2
"	1.0680	15–16	77.8
Mn_2SO_4	1.1119	15–16	79.1
"	1.0329	15–16	77.3
$ZnSO_4$	1.3981	15–16	83.3
"	1.2830	15–16	80.7
"	1.1039	15–16	77.8

* This determination of the capillary constants of liquids has been the subject of many careful experiments, but the results of the different experimenters, and even of the same observer when the method of measurement is changed, do not agree well together. The values here quoted can only be taken as approximations to the actual values for the liquids in a state of purity in contact with pure air. In the case of water the values given by Lord Rayleigh from the wave length of ripples (Phil. Mag. 1890) and by Hall from direct measurement of the tension of a flat film (Phil. Mag. 1893) have been preferred, and the temperature correction has been taken as 0.141 dyne per degree centigrade. The values for alcohol were derived from the experiments of Hall above referred to and the experiments on the effect of temperature made by Timberg (Wied. Ann. vol. 30).

The authority for a few of the other values given is quoted, but they are for the most part average values derived from a large number of results published by different experimenters.

† From Volkmann (Wied. Ann. vol. 17, p. 353).

TENSION OF LIQUIDS.

TABLE 143. — Surface Tension of Liquids.*

Liquid.	Specific gravity.	Surface tension in dynes per centimetre of liquid in contact with — Air.	Water.	Mercury.
Water	1.0	75.0	0.0	(392)
Mercury	13.543	513.0	392.0	0
Bisulphide of carbon	1.2687	30.5	41.7	(387)
Chloroform	1.4878	(31.8)	26.8	(415)
Ethyl alcohol	0.7906	(24.1)	–	364
Olive oil	0.9136	34.6	18.6	317
Turpentine	0.8867	28.8	11.5	241
Petroleum	9.7977	29.7	(28.9)	271
Hydrochloric acid	1.10	(72.9)	–	(392)
Hyposulphite of soda solution	1.1248	69.9	–	429

TABLE 144. — Surface Tension of Liquids at Solidifying Point.†

Substance.	Temperature of solidification. Cent.°	Surface tension in dynes per centimetre.	Substance.	Temperature of solidification. Cent.°	Surface tension in dynes per centimetre.
Platinum	2000	1691	Antimony	432	249
Gold	1200	1003	Borax	1000	216
Zinc	360	877	Carbonate of soda	1000	210
Tin	230	599	Chloride of sodium	–	116
Mercury	—40	588	Water	0	87.9‡
Lead	330	457	Selenium	217	71.8
Silver	1000	427	Sulphur	111	42.1
Bismuth	265	1390	Phosphorus	43	42.0
Potassium	58	371	Wax	68	34.1
Sodium	90	258			

TABLE 145. — Tension of Soap Films.

Elaborate measurements of the thickness of soap films have been made by Reinold and Rucker.‖ They find that a film of oleate of soda solution containing 1 of soap to 70 of water, and having 3 per cent of KNO_3 added to increase electrical conductivity, breaks at a thickness varying between 7.2 and 14.5 micro-millimetres, the average being 12.1 micro-millimetres. The film becomes black and apparently of nearly uniform thickness round the point where fracture begins. Outside the black patch there is the usual display of colors, and the thickness at these parts may be estimated from the colors of thin plates and the refractive index of the solution (*vide* Newton's rings, Table 146).

When the percentage of KNO_3 is diminished, the thickness of the black patch increases. For example, KNO_3 = 3 1 0.5 0.0

Thickness = 12.4 13.5 14.5 22.1 micro-mm.

A similar variation was found in the other soaps.

It was also found that diminishing the proportion of soap in the solution, there being no KNO_3 dissolved, increased the thickness of the film.

1 part soap to 30 of water gave thickness 21.6 micro-mm.
1 part soap to 40 of water gave thickness 22.1 micro-mm.
1 part soap to 60 of water gave thickness 27.7 micro-mm.
1 part soap to 80 of water gave thickness 29.3 micro-mm.

* This table of tensions at the surface separating the liquid named in the first column and air, water or mercury as stated at the head of the last three columns, is from Quincke's experiments (Pogg. Ann. vol. 139, and Phil. Mag. 1871). The numbers given are the equivalent in degrees per centimetre of those obtained by Worthington from Quincke's results (Phil. Mag. vol. 20, 1885) with the exception of those in brackets, which were not corrected by Worthington; they are probably somewhat too high, for the reason stated by Worthington. The temperature was about 20° C.

† Quincke, "Pogg. Ann." vol. 135, p. 661.

‡ It will be observed that the value here given on the authority of Quincke is much higher than his subsequent measurements, as quoted above, give.

‖ "Proc. Roy. Soc." 1877, and "Phil. Trans. Roy. Soc." 1881, 1883, and 1893.

NOTE. — Quincke points out that substances may be divided into groups in each of which the ratio of the surface tension to the density is nearly constant. Thus, if this ratio for mercury be taken as unit, the ratio for the bromides and iodides is about a half: that of the nitrates, chlorides, sugars, and fats, as well as the metals, lead, bismuth, and antimony, about 1; that of water, the carbonates, sulphates, and probably phosphates, and the metals platinum, gold, silver, cadmium, tin, and copper, 2; that of zinc, iron, and palladium, 3; and that of sodium, 6.

NEWTON'S RINGS.

Newton's Table of Colors.

The following table gives the thickness in millionths of an inch, according to Newton, of a plate of air, water, and glass corresponding to the different colors in successive rings commonly called colors of the first, second, third, etc., orders.

Order.	Color for reflected light.	Color for transmitted light.	Thickness in millionths of an inch for — Air.	Water.	Glass.
I.	Very black	—	0.5	0.4	0.2
	Black . .	White . .	1.0	0.75	0.9
	Beginning of black .	—	2.0	1.5	1.3
	Blue . .	Yellowish red . .	2.4	1.8	1.5
	White . .	Black . .	5.2	3.9	3.4
	Yellow . .	Violet .	7.1	5.3	4.6
	Orange .	—	8.0	6.0	4.2
	Red . . .	Blue . .	9.0	6.7	5.8
II.	Violet . .	White .	11.2	3.4	7.2
	Indigo . .	—	12.8	9.6	8.4
	Blue . .	Yellow .	14.0	10.5	9.0
	Green . .	Red . .	15.1	11.3	9.7
	Yellow . .	Violet .	16.3	12.2	10.4
	Orange .	—	17.2	13.0	11.3
	Bright red	Blue . .	18.2	13.7	11.8
	Scarlet . .	—	19.7	14.7	12.7
III.	Purple . .	Green .	21.0	15.7	13.5
	Indigo . .	—	21.1	17.6	14.2
	Blue . .	Yellow .	23.2	17.5	15.1
	Green . .	Red . .	25.2	18.6	16.2

Order.	Color for reflected light.	Color for transmitted light.	Thickness in millionths of an inch for — Air.	Water.	Glass.
	Yellow . .	Bluish green	27.1	20.3	17.5
	Red . . .	—	29.0	21.7	18.7
	Bluish red	—	32.0	24.0	20.7
IV.	Bluish green .	—	24.0	25.5	22.0
	Green . .	Red .	35.3	26.5	22.7
	Yellowish green .	—	36.0	27.0	23.2
	Red . . .	Bluish green	40.3	30.2	26.0
V.	Greenish blue . .	Red .	46.0	34.5	39.7
	Red . . .	—	52.5	39.4	34.0
VI.	Greenish blue . .	—	58.7	46	38.0
	Red . . .	—	65.0	48.7	42.0
VII.	Greenish blue . .	—	72.0	53.2	45.8
	Reddish white .	—	71.0	57.7	49.4

The above table has been several times revised both as to the colors and the numerical values. Professors Reinold and Rucker, in their investigations on the measurement of the thickness of soap films, found it necessary to make new determinations. They give a shorter series of colors, as they found difficulty in distinguishing slight differences of shade, but divide each color into ten parts and tabulate the variation of thickness in terms of the tenth of a color band. The position in the band at which the thickness is given and the order of color are indicated by numerical subscripts. For example: $R_{1\,5}$ indicates the red of the first order and the fifth tenth from the edge furthest from the red edge of the spectrum. The thicknesses are in millionths of a centimetre.

Order.	Color.	Position.	Thickness.
I.	Red * .	$R_{1\,5}$	28.4
II.	Violet .	$V_{2\,5}$	30.5
	Blue . .	$B_{2\,5}$	35.3
	Green .	$G_{2\,5}$	40.9
	Yellow *	$Y_{2\,5}$	45.4
	Orange *	$O_{2\,5}$	49.1
	Red . .	$R_{2\,5}$	52.2
III.	Purple .	$P_{3\,5}$	·55.9
	Blue . .	$B_{3\,0}$	57.7
	Blue * .	$B_{3\,5}$	60.3
	Green .	$G_{3\,5}$	65.6
	Yellow *	$Y_{3\,5}$	71.0

Order.	Color.	Position.	Thickness.
	Red * .	$R_{3\,5}$	76.5
	Bluish red * .	$BR_{3\,5}$	81.5
IV.	Green .	$G_{4\,0}$	84.1
	" .	$G_{4\,5}$	89.3
	Yellow green *	$YG_{4\,5}$	96.4
	Red * .	$R_{4\,5}$	105.2
V.	Green .	$G_{5\,0}$	111.9
	Green *.	$G_{5\,5}$	118.8
	Red . .	$R_{5\,0}$	126.0
	Red * .	$R_{5\,5}$	133.5

Order.	Color.	Position.	Thickness.
VI.	Green .	$G_{6\,0}$	141.0
	Green *	$G_{6\,5}$	147.9
	Red . .	$R_{6\,0}$	154.8
	Red * .	$R_{6\,5}$	162.7
VII.	Green .	$G_{7\,0}$	170.5
	Green *.	$G_{7\,5}$	178.7
	Red . .	$R_{7\,0}$	186.9
	Red * .	$R_{7\,5}$	193.6
VIII.	Green .	$G_{8\,0}$	200.4
	Red . .	$R_{8\,0}$	211.5

* The colors marked are the same as the corresponding colors in Newton's table.

CONTRACTION PRODUCED BY SOLUTION.*

Across the top of the heading are given the formulas of the salt dissolved, its molecular weight (M. W.), and the density of the salt, with the authority for that density.

K_2O.
M. W. = 47.02. Density = 2.656 (Karsten).

Grammes of the salt in 100 of water.	Observed volume. (Hager.)	Calculated volume.	Per cent of contraction.
4.702	99.88	101.77	1.86
9.404	99.92	103.55	4.20
14.106	100.18	105.32	4.88
18.808	100.60	107.09	6.06
23.510	101.20	108.86	7.04
28.212	102.00	110.64	7.81
32.914	102.90	112.41	8.46
37.616	103.90	114.18	9.01
42.318	104.96	115.96	9.80
47.020	106.10	117.73	9.88
70.530	112.20	126.59	11.37
79.934	114.88	130.14	11.73

KOH.
M. W. = 56. Density = 2.044 (Filhol).

Grammes of the salt in 100 of water.	Observed volume. (Schiff.)	Calculated volume.	Per cent of contraction.
5.6	101.2	102.74	1.50
11.2	102.6	105.48	2.73
16.8	104.0	108.22	3.90
22.4	105.4	110.26	5.01
28.0	106.8	113.70	6.07
33.6	108.4	116.44	6.91
39.2	110.0	119.18	7.70
44.8	111.6	121.92	8.46
50.4	113.2	124.66	9.19
56.0	115.0	127.40	9.72
84.0	124.2	141.10	11.98
112.0	134.6	154.80	13.05
168.0	157.6	182.20	13.50
224.0	181.8	209.60	13.26

Na_2O.
M. W. = 30.97. Density = 2.805 (Karsten).

Grammes of the salt in 100 of water.	Observed volume. (Hager.)	Calculated volume.	Per cent of contraction.
3.097	99.01	101.10	2.07
6.194	98.26	102.21	3.86
9.291	97.76	103.31	5.37
12.388	97.45	104.42	6.67
15.485	97.29	105.52	7.80
18.582	97.23	106.63	8.81
21.679	97.32	107.73	9.66
24.776	97.55	108.83	10.37
27.873	97.84	109.94	11.00
30.970	98.20	111.04	11.56
46.455	100.94	116.56	13.40
52.649	102.30	118.77	13.87

NaOH.
M. W. = 39.95. Density = 2.130 (Filhol).

Grammes of the salt in 100 of water.	Observed volume. (Schiff.)	Calculated volume.	Per cent of contraction.
3.995	99.4	101.88	2.43
7.990	99.4	103.75	4.19
11.985	99.6	105.63	5.71
15.980	100.2	107.50	6.79
19.975	100.8	109.38	7.84
23.970	101.7	111.26	8.59
27.965	102.7	113.13	9.22
31.960	103.8	115.01	9.75
35.955	105.0	116.88	10.17
39.950	106.2	118.76	10.58
59.925	113.4	128.14	11.50
79.900	121.2	137.52	11.87
119.850	138.6	156.28	11.31
159.800	156.6	175.04	10.54
199.750	174.8	193.80	9.80
239.970	193.6	212.56	8.92

NH_3.
M. W. = 17. Density = 0.616 (Andreef).

Grammes of the salt in 100 of water.	Observed volume. (Carius.)	Calculated volume.	Per cent of contraction.
1.7	102.5	102.76	0.25
3.4	105.0	105.52	0.49
5.1	107.4	108.28	0.81
6.8	109.8	111.04	1.12
8.5	112.2	113.80	1.41
10.2	114.6	116.56	1.68
11.9	117.0	119.32	1.95
13.6	119.4	122.08	2.20
15.3	121.8	124.84	2.44
17.0	124.2	127.60	2.66
25.5	135.8	141.40	3.96
34.0	147.3	155.20	5.09
51.0	169.7	182.80	7.17

NH_4Cl.
M. W. = 53.38. Density = 1.52 (Schroeder).

Grammes of the salt in 100 of water.	Observed volume. (Gerlach.)	Calculated volume.	Per cent of contraction.
5.338	103.7	103.51	0.18
10.676	107.5	107.02	0.45
16.014	111.5	110.54	0.87
21.352	115.3	114.05	1.10
26.690	119.2	117.56	1.40

* The table was compiled from a paper by Gerlach (Zeits. für Anal. Chem. vol. 27).

TABLE 147.

CONTRACTION PRODUCED BY SOLUTION.

KCl. M. W. = 74.41. Density = 1.945 (Clarke).

Grammes of the salt in 100 of water.	Observed volume. (Gerlach.)	Calculated volume.	Per cent of contraction.
7.441	102.8	103.83	0.99
14.882	105.8	107.65	1.72
22.323	108.9	111.48	2.31

NaCl. M. W. = 58.36. Density = 2.150 (Clarke).

Grammes of the salt in 100 of water.	Observed volume. (Gerlach.)	Calculated volume.	Per cent of contraction.
5.836	101.7	102.71	0.99
11.672	103.7	105.43	1.64
17.508	105.8	108.14	2.16
23.344	107.9	110.86	2.67
29.180	110.1	113.58	3.06

LiCl. M. W. = 42. Density = 1.980 (Gerlach).

Grammes of the salt in 100 of water.	Observed volume. (Gerlach.)	Calculated volume.	Per cent of contraction.
4.2	101.9	102.14	0.24
8.4	103.8	104.28	0.46
12.6	105.8	106.42	0.58
16.8	107.8	108.56	0.70
21.0	110.0	110.70	0.63
42.0	120.7	121.40	0.58

$CaCl_2$. M. W. = 110.64. Density = 2.216 (Schroeder).

Grammes of the salt in 100 of water.	Observed volume. (Gerlach.)	Calculated volume.	Per cent of contraction.
5.532	101.2	102.50	1.26
11.064	102.2	104.99	2.66
16.596	103.5	107.49	3.71
22.128	104.8	109.99	4.72
27.660	106.3	112.48	5.50
33.192	108.0	114.98	6.07
66.384	118.6	129.96	8.74

$SrCl_2$. M. W. = 157.94. Density = 3.05 (Schroeder).

Grammes of the salt in 100 of water.	Observed volume. (Gerlach.)	Calculated volume.	Per cent of contraction.
7.895	101.4	102.59	1.16
15.790	102.5	105.17	2.55
23.685	104.0	107.76	3.43
31.580	105.5	110.34	4.39
39.475	107.2	112.93	5.07

$BaCl_2$. M. W. = 207.54. Density = 3.75 (Schroeder).

Grammes of the salt in 100 of water.	Observed volume. (Gerlach.)	Calculated volume.	Per cent of contraction.
10.377	101.6	102.77	1.14
20.754	102.9	105.53	2.50
31.131	104.9	108.30	3.14

KI. M. W. = 166.57. Density = 3.07 (Clarke).

Grammes of the salt in 100 of water.	Observed volume. (Kremers.)	Calculated volume.	Per cent of contraction.
16.657	104.5	105.39	0.85
33.314	109.3	110.77	1.34
49.971	114.2	116.18	1.70
66.628	119.1	121.57	2.20
83.285	124.0	126.97	2.34

$KClO_3$. M. W. = 122.29. Density = 2.331 (Clarke).

Grammes of the salt in 100 of water.	Observed volume. (Kremers.)	Calculated volume.	Per cent of contraction.
6.114	102.3	102.62	0.314

KNO_3. M. W. = 100.93. Density = 2.092 (Clarke).

Grammes of the salt in 100 of water.	Observed volume. (Gerlach.)	Calculated volume.	Per cent of contraction.
5.046	101.90	102.41	0.50
10.093	104.84	104.83	0.79
20.186	108.40	109.65	1.14

$NaNO_3$. M. W. = 84.88. Density = 2.244 (Clarke).

Grammes of the salt in 100 of water.	Observed volume. (Kremers.)	Calculated volume.	Per cent of contraction.
8.488	102.9	103.78	0.85
16.976	106.1	107.56	1.36
42.440	116.2	118.91	2.28
84.880	134.3	137.82	2.55

NH_4NO_3. M. W. = 79.90. Density = 1.74 (Schroeder).

Grammes of the salt in 100 of water.	Observed volume. (Gerlach.)	Calculated volume.	Per cent of contraction.
7.990	104.6	104.59	0.076
15.980	109.3	109.18	0.106
39.950	124.4	122.96	1.170
79.900	149.8	145.92	2.660

CONTRACTION PRODUCED BY SOLUTION.

$Ca(NO_3)_2$.
M. W. = 163.68. Density = 2.36 (Clarke).

Grammes of the salt in 100 of water.	Observed volume.	Calculated volume.	Per cent of contraction.
	(Gerlach.)		
1.637	100.45	100.69	0.24
3.274	100.90	101.39	0.48
4.910	101.35	102.08	0.72
6.547	101.85	102.77	0.90
8.184	102.30	103.47	1.13
16.368	104.70	106.94	2.09
32.736	109.90	113.87	3.49
49.104	115.55	120.81	4.35
65.472	121.50	127.74	4.89
81.840	127.65	134.68	5.22

$Ba(NO_3)_2$.
M. W. = 260.58. Density = 3.23 (Clarke).

Grammes of the salt in 100 of water.	Observed volume.	Calculated volume.	Per cent of contraction.
	(Gerlach.)		
2.606	100.5	100.81	0.30
5.212	101.0	101.61	0.60
7.817	101.5	102.42	0.90

$Sr(NO_3)_2$.
M. W. = 210.98. Density = 2.93 (Clarke).

Grammes of the salt in 100 of water.	Observed volume.	Calculated volume.	Per cent of contraction.
	(Gerlach.)		
2.110	100.48	100.72	0.24
4.220	100.95	101.44	0.48
6.329	101.40	102.16	0.74
8.439	101.95	102.88	0.90
10.549	102.45	103.60	1.11
21.098	104.95	107.20	2.10
42.196	110.20	114.40	3.67
63.294	116.15	121.60	4.48

$Pb(NO_3)_2$.
M. W. = 165.09. Density = 4.41 (Clarke).

Grammes of the salt in 100 of water.	Observed volume.	Calculated volume.	Per cent of contraction.
	(Gerlach.)		
16.509	102.4	103.74	1.29
33.018	105.1	107.49	2.22
82.545	114.0	118.72	3.97

K_2CO_3.
M. W. = 137.93. Density 2.29 (Clarke and Schroeder).

Grammes of the salt in 100 of water.	Observed volume.	Calculated volume.	Per cent of contraction.
	(Gerlach.)		
6.897	100.96	103.01	1.99
13.793	102.22	106.02	3.59
20.689	103.78	109.08	4.82
27.586	105.44	112.05	5.90
68.965	118.20	130.12	9.16
96.551	128.10	142.16	9.89

Na_2CO_3.
M. W. = 105.83. Density 2.476 (Clarke and Schroeder).

Grammes of the salt in 100 of water.	Observed volume.	Calculated volume.	Per cent of contraction.
	(Gerlach.)		
5.292	100.00	102.14	2.09
10.582	100.44	104.27	3.68
15.875	101.06	106.41	5.03

K_2SO_4.
M. W. = 173.90. Density 2.647 (Clarke).

Grammes of the salt in 100 of water.	Observed volume.	Calculated volume.	Per cent of contraction.
	(Gerlach.)		
8.695	101.94	103.29	1.30

$(NH_4)_2SO_4$.
M. W. = 131.84. Density 1.762 (Clarke).

Grammes of the salt in 100 of water.	Observed volume.	Calculated volume.	Per cent of contraction.
	(Schiff.)		
6.592	102.92	103.74	0.792
13.184	105.96	107.48	1.418
19.776	109.20	112.26	1.821
26.369	112.60	114.97	2.060
65.920	135.20	137.42	1.615
98.880	154.50	156.13	1.044

$FeSO_4$.
M. W. = 151.72. Density 2.99 (Clarke).

Grammes of the salt in 100 of water.	Observed volume.	Calculated volume.	Per cent of contraction.
	*		
7.586	100.52	102.54	1.97
15.172	101.30	105.07	3.59
22.758	102.40	107.61	4.84
30.344	103.70	110.15	5.85

$MgSO_4$.
M. W. = 197.6. Density 2.65 (Clarke).

Grammes of the salt in 100 of water.	Observed volume.	Calculated volume.	Per cent of contraction.
	*		
5.988	100.13	102.26	2.08
11.976	100.40	104.52	3.94
17.964	101.26	106.78	5.16
23.952	102.10	109.04	6.36

Na_2SO_4.
M. W. = 141.80. Density = 2.656 (Clarke).

Grammes of the salt in 100 of water.	Observed volume.	Calculated volume.	Per cent of contraction.
	(Gerlach.)		
7.09	100.96	102.67	1.67
14.18	102.26	105.34	2.92

* Authority not given.

TABLE 147.

CONTRACTION PRODUCED BY SOLUTION.

Grammes of the salt in 100 of water.	Observed volume.	Calculated volume.	Per cent of contraction.
$ZnSO_4$. M. W. = 160.72. Density 3.49 (Clarke).			
	*		
8.036	100.06	102.30	2.19
16.072	100.44	104.61	3.98
24.108	101.08	106.91	5.45
32.144	101.90	109.21	6.69
40.180	102.86	111.51	7.76
$Al_2K_2(SO_4)_4$. M. W. = 128.99. Density = 2.228 (Clarke).			
	(Gerlach.)		
6.450	100.58	102.90	2.25
$NaC_2H_3O_2$. M. W. = 81.85. Density = 1.476 (Gerlach).			
	(Gerlach.)		
8.185	104.1	105.55	1.37
16.360	108.3	111.09	2.51
$Na_2C_4H_4O_6$. M. W. = 193.62. Density 1.83 (Gerlach).			
	(Gerlach.)		
19.362	106.6	110.57	3.59
38.724	114.2	121.15	5.74
$KC_2H_3O_2$. M. W. = 97.90. Density = 1.472 (Gerlach).			
	(Gerlach.)		
9.79	105.2	106.65	1.36
19.58	110.5	113.30	2.47
48.95	127.3	133.26	4.47
97.90	156.4	166.51	6.07
$K_2C_4H_4O_6$. M. W. = 225.72. Density 1.98 (Gerlach).			
	(Gerlach.)		
22.572	108.8	111.39	2.33
45.144	118.3	122.79	3.66
67.716	128.2	134.18	4.46
90.288	138.7	145.58	4.73
112.860	149.2	156.97	4.95
135.432	159.7	168.36	5.15
158.004	170.6	179.76	5.10
$Pb(C_2H_3O_2)_2$. M. W. = 162.06. Density 3.251 (Schroeder).			
	(Gerlach.)		
16.206	104.7	104.98	0.27
32.412	109.5	109.96	0.42
81.030	124.6	124.91	0.25

TABLE 148.

CONTRACTION DUE TO DILUTION OF A SOLUTION.†

The first column gives the name of the salt dissolved, the second the amount of the salt required to produce saturation and the third the contraction produced by mixing with an equal volume of water.

Water with equal volume of saturated solution of following salts.	Parts of anhydrate salt dissolved by 100 parts of H_2O at 10° C.	Contraction when mixed. Per cent.
KCl	31.97	0.325
K_2SO_4	10.10	0.082
KNO_3	20.77	0.144
K_2CO_3	88.72	2.682
$NaCl$	35.75	0.490
Na_2SO_4	8.04	0.107
$NaNO_3$	84.30	0.975
Na_2CO_3	16.66	0.206
NH_4Cl	36.60	0.273
$(NH_4)_2SO_4$	–	1.302
NH_4NO_3	185.00	0.772
$CaCl_2$	63.30	1.135
$BaCl_2$	33.30	0.235
$MgSO_4$	30.50	0.677
$ZnSO_4$	48.36	0.835
$FeSO_4$	19.90	0.327
$Al_2K_2(SO_4)_4$	4.99	0.033
$CuSO_4$	20.92	0.218
$Pb(NO_3)_2$	48.30	0.228

* Authority not given.
† R. Broom, "Proc. Roy. Soc. Edin." vol. 13, p. 172.

FRICTION.

The following table of coefficients of friction f and its reciprocal $1/f$, together with the angle of friction or angle of repose ϕ, is quoted from Rankine's "Applied Mechanics." It was compiled by Rankine from the results of General Morin and other authorities, and is sufficient for all ordinary purposes.

Material.	f	$1/f$	ϕ
Wood on wood, dry	.25–.50	4.00–2.00	14.0–26.5
" " " soapy	.20	5.00	11.5
Metals on oak, dry	.50–.60	2.00–1.67	26.5–31.0
" " " wet	.24–.26	4.17–3.85	13.5–14.5
" " " soapy	.20	5.00	11.5
" " elm, dry	.20–.25	5.00–4.00	11.5–14.0
Hemp on oak, dry	.53	1.89	28.0
" " " wet	.33	3.00	18.5
Leather on oak	.27–.38	3.70–2.86	15.0–19.5
" " metals, dry	.56	1.79	29.5
" " " wet	.36	2.78	20.0
" " " greasy	.23	4.35	13.0
" " " oily	.15	6.67	8.5
Metals on metals, dry	.15–.20	6.67–5.00	8.5–11.5
" " " wet	.3	3.33	16.5
Smooth surfaces, occasionally greased	.07–.08	14.3–12.50	4.0–4.5
" " continually greased	.05	20.00	3.0
" " best results	.03–.036	33.3–27.6	1.75–2.0
Steel on agate, dry *	.20	5.00	11.5
" " " oiled *	.107	9.35	6.1
Iron on stone	.30–.70	3.33–1.43	16.7–35.0
Wood on stone	About .40	2.50	22.0
Masonry and brick work, dry	.60–.70	1.67–1.43	33.0–35.0
" " " " damp mortar	.74	1.35	36.5
" on dry clay	.51	1.96	27.0
" " moist clay	.33	3.00	18.25
Earth on earth	.25–1.00	4.00–1.00	14.0–45.0
" " " dry sand, clay, and mixed earth	.38–.75	2.63–1.33	21.0–37.0
" " " damp clay	1.00	1.00	45.0
" " " wet clay	.31	3.23	17.0
" " " shingle and gravel	.81–1.11	1.23–0.9	39.0–48.0

* Quoted from a paper by Jenkin and Ewing, "Phil. Trans. R. S." vol. 167. In this paper it is shown that in cases where "static friction" exceeds "kinetic friction" there is a gradual increase of the coefficient of friction as the speed is reduced towards zero.

VISCOSITY.

The coefficient of viscosity is the tangential force per unit area of one face of a plate of the fluid which is required to keep up unit distortion between the faces. Viscosity is thus measured in terms of the temporary rigidity which it gives to the fluid. Solids may be included in this definition when only that part of the rigidity which is due to varying distortion is considered. One of the most satisfactory methods of measuring the viscosity of fluids is by the observation of the rate of flow of the fluid through a capillary tube, the length of which is great in comparison with its diameter. Poiseuille * gave the following formula for calculating the viscosity coefficient in this case: $\mu = \frac{\pi h r^4 s}{8 v l}$, where h is the pressure height, r the radius of the tube, s the density of the fluid, v the quantity flowing per unit time, and l the length of the capillary part of the tube. The liquid is supposed to flow from an upper to a lower reservoir joined by the tube, hence h and l are different. The product hs is the pressure under which the flow takes place. Hagenbach † pointed out that this formula is in error if the velocity of flow is sensible, and suggested a correction which was used in the calculation of his results. The amount to be subtracted from h, according to Hagenbach, is $\frac{v^2}{\sqrt{2g}}$, where g is the acceleration due to gravity. Gartenmeister ‡ points out an error in this to which his attention had been called by Finkener, and states that the quantity to be subtracted from h should be simply $\frac{v^2}{g}$; and this formula is used in the reduction of his observations. Gartenmeister's formula is the most accurate, but all of them nearly agree if the tube be long enough to make the rate of flow very small. None of the formulæ take into account irregularities in the distortion of the fluid near the ends of the tube, but this is probably negligible in all cases here quoted from, although it probably renders the results obtained by the "viscosimeter" commonly used for testing oils useless for our purpose.

The term "specific viscosity" is sometimes used in the headings of the tables; it means the ratio of the viscosity of the fluid under consideration to the viscosity of water at a specified temperature.

TABLE 150.—Specific Viscosity of Water at different Temperatures relative to Water at 0° C.

Temp. in C°.	Authorities.							Mean value.	Absolute value in C. G. S. units.
	Poiseuille.	Graham.		Rellstab.	Sprung.	Wagner.	Slotte.		
0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0178§
5	85.2	84.4	84.8	85.3	84.9	–	–	84.9	0.0151
10	73.5	73.6	72.9	73.5	73.2	–	–	73.3	0.0131
15	64.3	63.5	63.7	63.0	63.9	63.9	–	63.7	0.0113
20	56.7	56.0	56.0	55.5	56.2	56.2	56.4	56.2	0.0100
25	–	49.5	50.5	48.7	50.5	50.3	–	49.9	0.0089
30	45.2	44.7	45.0	45.0	45.2	44.6	45.2	45.0	0.0080
35	–	40.2	41.1	40.0	40.8	40.3	–	40.5	0.0072
40	–	36.8	37.0	37.2	37.0	36.7	36.9	36.9	0.0066
45	–	33.9	33.9	34.5	34.0	34.5	–	34.2	0.0061
50	30.8	31.1	31.1	31.2	31.3	31.7	–	31.2	0.0056

* "Comptes rendus," vol. 15, 1842. "Mém. Serv. Etr." 1846.

† "Pogg. Ann." vol. 109, 1860.

‡ "Zeits. für Phys. Chim." vol. 6, 1890.

§ The value 0.0178 is taken from a paper by Crookes (Phil. Trans. R. S. L. 1886), where the coefficient is given as $\mu = 0.0177931 P$, where $P^{-1} = 1 + .0336793 T + .0002209936 T^2$, where T is the temperature of the water in degrees Centigrade. The numbers in the table were calculated not from the formula but from the numbers in the column headed "mean value."

VISCOSITY.

TABLE 151. — Solution of Alcohol in Water.*

Coefficients of viscosity, in C. G. S. units, for solution of alcohol in water.

Temp. C.	Percentage by weight of alcohol in the mixture.								
	0	8.21	16.60	34.58	43.99	53.36	75.75	87.45	99.72
0°	0.0181	0.0287	0.0453	0.0732	0.0707	0.0632	0.0407	0.0294	0.0180
5	.0152	.0234	.0351	.0558	.0552	.0502	.0344	.0256	.0163
10	.0131	.0195	.0281	.0435	.0438	.0405	.0292	.0223	.0148
15	.0114	.0165	.0230	.0347	.0353	.0332	.0250	.0195	.0134
20	.0101	.0142	.0193	.0283	.0286	.0276	.0215	.0172	.0122
25	0.0090	0.0123	0.0163	0.0234	0.0241	0.0232	0.0187	0.0152	0.0110
30	.0081	.0108	.0141	.0196	.0204	.0198	.0163	.0135	.0100
35	.0073	.0096	.0122	.0167	.0174	.0171	.0144	.0120	.0092
40	.0067	.0086	.0108	.0143	.0150	.0149	.0127	.0107	.0084
45	.0061	.0077	.0095	.0125	.0131	.0130	.0113	.0097	.0077
50	0.0056	0.0070	0.0085	0.0109	0.0115	0.0115	0.0102	0.0088	0.0070
55	.0052	.0063	.0076	.0096	.0102	.0102	.0091	.0086	.0065
60	.0048	.0058	.0069	.0086	.0091	.0092	.0083	.0073	.0060

The following tables (152–153) contain the results of a number of experiments in the viscosity of mineral oils derived from petroleum residues and used for lubricating purposes.†

TABLE 152. — Mineral Oils.‡

Density.	Flashing point. ° C.	Burning point. ° C.	Sp. viscosity. Water at 20° C. = 1. 20° C.	50° C.	100° C.
.931	243	274	–	11.30	2.9
.921	216	246	–	7.31	2.5
.906	189	208	–	3.45	1.5
.921	163	190	–	27.80	2.8
.917	132	168	–	–	2.6
.904	170	207	8.65	2.65	1.7
.891	151	182	4.77	1.86	1.3
.878	108	148	2.94	1.48	–
.855	42	45	1.65	–	–
.905	165	202	–	3.10	1.5
.894	139	270	7.60	3.60	1.3
.866	90	224	2.50	1.50	–

TABLE 153. — Mineral Oils.

Oil.	Density.	Flashing point. ° C.	Burning point. ° C.	Viscosity at 19° C., water at 19° C. = 1.
Cylinder oil	.917	227	274	191
Machine oil	.914	213	260	102
Wagon oil	.914	148	182	80
" "	.911	157	187	70
Naphtha residue	.910	134	162	55
Oleo-naphtha	.910	219	257	121
" "	.904	201	242	66
" "	.894	184	222	26
Oleonid	.884	185	217	28
" best quality	.881	188	224	20
Olive oil	.916	–	–	22
Whale oil	.879	–	–	9
" "	.875	–	–	8

* This table was calculated from the table of fluidities given by Noack (Wied. Ann. vol. 27, p. 217), and shows a maximum for a solution containing about 40 per cent of alcohol. A similar result was obtained for solutions of acetic acid.

† Table 152 is from a paper by Engler in Dingler's "Poly. Jour." vol. 268, p. 76, and Table 153 is from a paper by Lamansky in the same journal, vol. 248, p. 29. The very mixed composition of these oils renders the viscosity a very uncertain quantity, neither the density nor the flashing point being a good guide to viscosity.

‡ The different groups in this table are from different residues.

VISCOSITY.

This table gives some miscellaneous data as to the viscosity of liquids, mostly referring to oils and paraffins. The viscosities are in C. G. S. units.

Liquid.	G. %	Coefficient of viscosity.	Temp. Cent. °	Authority.
Ammonia		0.0160	11.9	Poiseuille.
“		0.0149	14.5	“
Anisol		0.0111	20.0	Gartenmeister.
Glycerine		42.20	2.8	Schottner.
“		25.18	8.1	“
“		13.87	14.3	“
“		8.30	20.3	“
“		4.94	26.5	“
Glycerine and water	94.46	7.437	8.5	“
“ “	80.31	1.021	8.5	“
“ “	64.05	0.222	8.5	“
“ “	49.79	0.092	8.5	“
Glycol		0.0219	0.0	Arrhenius.
Mercury *		0.0184	—20	Koch.
“		0.0170	0.0	“
“		0.0157	20.0	“
“		0.0122	100.0	“
“		0.0102	200.0	“
“		0.0093	300.0	“
Meta-cresol		0.1878	20.0	Gartenmeister.
Olive oil		3.2653†	0.0	Reynolds.
Paraffins: Decane		0.0077	22.3	Bartolli & Stracciati.
Dodecane		0.0126	23.3	“ “
Heptane		0.0045	24.0	“ “
Hexadecane		0.0359	22.2	“ “
Hexane		0.0033	23.7	“ “
Nonane		0.0062	22.3	“ “
Octane		0.0053	22.2	“ “
Pentane		0.0026	21.0	“ “
Pentadecane		0.0281	22.0	“ “
Tetradecane		0.0213	21.9	“ “
Tridecane		0.0155	23.3	“ “
Undecane		0.0095	22.7	“ “
Petroleum (Caucasian)		0.0190	17.5	Petroff.
Rape oil		25.3	0.0	O. E. Meyer.
“ “		3.85	10.0	“
“ “		1.63	20.0	“
“ “		0.96	30.0	“

* Calculated from the formula $\mu = .017 - .000066t + .00000021t^2 - .0000000000025t^3$ (vide Koch, Wied. Ann. vol. 14 p. 1).

† Given as $= 3.2653\, e^{-.0128T}$, where T is temperature in Centigrade degrees.

VISCOSITY.

This table gives the viscosity of a number of liquids together with their temperature variation. The headings are temperatures in Centigrade degrees, and the numbers under them the coefficients of viscosity in C. G. S. units.*

Liquid.	Temperatures Centigrade.					Authority.
	10°	20°	30°	40°	50°	
Acetone	.0043	.0039	.0036	.0032	.0028	Pribram & Handl.
Acetates: Allyl	.0068	.0061	.0054	.0049	.0044	" "
Amyl	.0106	.0089	.0077	.0065	.0058	" "
Ethyl	.0051	.0044	.0040	.0035	.0032	" "
Methyl	.0046	.0041	.0036	.0032	.0030	" "
Propyl	.0066	.0059	.0052	.0044	.0039	" "
Acids: † Acetic	.0150	.0126	.0109	.0094	.0082	" "
Butyric	.0196	.0163	.0136	.0118	.0102	Gartenmeister.
Formic	.0231	.0184	.0149	.0125	.0104	"
Propionic	.0125	.0107	.0092	.0081	.0073	Rellstab.
"	.0139	.0118	.0101	.0091	.0080	Pribram & Handl.
Salicylic	.0320	.0271	.0222	.0181	.0150	Rellstab.
Valeric	.0271	.0220	.0183	.0155	.0127	"
Alcohols: Allyl	.0206	.0163	.0128	.0103	.0083	Pribram & Handl.
Amyl	.0651	.0470	.0344	.0255	.0196	" "
Butyl	.0424	.0324	.0247	.0190	.0150	" "
Ethyl	.0150	.0122	.0102	.0085	.0072	Gartenmeister.
Isobutyl	.0580	.0411	.0301	.0223	.0170	"
Isopropyl	.0338	.0248	.0185	.0140	.0108	"
Methyl	.0073	.0062	.0054	.0047	.0041	"
Propyl	.0293	.0227	.0179	.0142	.0115	"
Aldehyde	.0037	.0037	–	–	–	Rellstab.
Aniline	–	.0440	.0319	.0241	.0189	Wijkander.
Benzene	.0073	.0064	.0055	.0048	.0043	"
Benzoates: Ethyl	.0265	.0217	.0174	.0146	.0124	Rellstab.
Methyl	.0231	.0196	.0160	.0134	.0115	"
Bromides: Allyl	.0061	.0053	.0048	.0045	.0041	Pribram & Handl.
Ethyl	.0043	.0037	.0035	–	–	" "
Ethylene	–	.0169	.0149	–	–	" "
Carbon disulphide	–	.0036	.0035	.0034	–	Wijkander.
Carbon dioxide (liquid)	.0008	.0007	.0005	–	–	Warburg & Babo.
Chlorides: Allyl	.0039	.0036	.0033	–	–	Pribram & Handl.
Ethylene	–	.0083	.0072	.0063	.0056	" "
Chloroform	.0064	.0057	.0052	.0046	.0043	" "
Ether	.0026	.0023	.0021	–	–	" "
Ethyl sulphide	.0048	.0043	.0039	.0035	.0032	" "
Iodides: Allyl	.0080	.0072	.0065	.0059	.0053	" "
Ethyl	.0064	.0057	.0052	.0048	.0044	" "
Metaxylol	.0075	.0066	.0058	.0052	.0047	" "
Nitro benzene	–	.0203	.0170	.0144	.0124	" "
" butane	.0119	.0103	.0089	.0078	.0069	" "
" ethane	.0080	.0071	.0064	.0057	.0052	" "
" propane	.0099	.0087	.0077	.0068	.0061	" "
" toluene	–	.0233	.0190	.0159	.0136	" "
Propyl aldehyde	.0047	.0041	.0036	.0033	–	" "
Toluene	.0068	.0059	.0052	.0047	.0042	" "

* Calculated from the specific viscosities given in Landolt & Boernstein's "Phys. Chem. Tab." p. 289 *et seq.*, on the assumption that the coefficient for water at 0° C. is .0178.

† For inorganic acids, see Solutions.

VISCOSITY OF SOLUTIONS.

This table is intended to show the effect of change of concentration and change of temperature on the viscosity of solutions of salts in water. The specific viscosity × 100 is given for two or more densities and for several temperatures in the case of each solution. μ stands for specific viscosity, and t for temperature Centigrade.

Salt.	Percentage by weight of salt in solution.	Density.	μ	t	μ	t	μ	t	μ	t	Authority.
$BaCl_2$	7.60	–	77.9	10	44.0	30	35.2	50	–	–	Sprung.
"	15.40	–	86.4	"	56.0	"	39.6	"	–	–	"
"	24.34	–	100.7	"	66.2	"	47.7	"	–	–	"
$Ba(NO_3)_2$	2.98	1.027	62.0	15	51.1	25	42.4	35	34.8	45	Wagner.
"	5.24	1.051	68.1	"	54.2	"	44.1	"	36.9	"	"
$CaCl_2$	15.17	–	110.9	10	71.3	30	50.3	50	–	–	Sprung.
"	31.60	–	272.5	"	177.0	"	124.0	"	–	–	"
"	39.75	–	670.0	"	379.0	"	245.5	"	–	–	"
"	44.09	–	–	–	593.1	"	363.2	"	–	–	"
$Ca(NO_3)_2$	17.55	1.171	93.8	15	74.6	25	60.0	35	49.9	45	Wagner.
"	30.10	1.274	144.1	"	112.7	"	90.7	"	75.1	"	"
"	40.13	1.386	242.6	"	217.1	"	156.5	"	128.1	"	"
$CdCl_2$	11.09	1.109	77.5	15	60.5	25	49.1	35	40.7	45	"
"	16.30	1.181	88.9	"	70.5	"	57.5	"	47.2	"	"
"	24.79	1.320	104.0	"	80.4	"	64.6	"	53.6	"	"
$Cd(NO_3)_2$	7.81	1.074	61.9	15	50.1	25	41.1	35	34.0	45	"
"	15.71	1.159	71.8	"	58.7	"	48.8	"	41.3	"	"
"	22.36	1.241	85.1	"	69.0	"	57.3	"	47.5	"	"
$CdSO_4$	7.14	1.068	78.9	15	61.8	25	49.9	35	41.3	45	"
"	14.66	1.159	96.2	"	72.4	"	58.1	"	48.8	"	"
"	22.01	1.268	120.8	"	91.8	"	73.5	"	60.1	"	"
$CoCl_2$	7.97	1.081	83.0	15	65.1	25	53.6	35	44.9	45	"
"	14.86	1.161	111.6	"	85.1	"	73.7	"	58.8	"	"
"	22.27	1.264	161.6	"	126.6	"	101.6	"	85.6	"	"
$Co(NO_3)_2$	8.28	1.073	74.7	15	57.9	25	48.7	35	39.8	45	"
"	15.96	1.144	87.0	"	69.2	"	55.4	"	44.9	"	"
"	24.53	1.229	110.4	"	88.0	"	71.5	"	59.1	"	"
$CoSO_4$	7.24	1.086	86.7	15	68.7	25	55.0	35	45.1	45	"
"	14.16	1.159	117.8	"	95.5	"	76.0	"	61.7	"	"
"	21.17	1.240	193.6	"	146.2	"	113.0	"	89.9	"	"
$CuCl_2$	12.01	1.104	87.2	15	67.8	25	55.1	35	45.6	45	"
"	21.35	1.215	121.5	"	95.8	"	77.0	"	63.2	"	"
"	33.03	1.331	178.4	"	137.2	"	107.6	"	87.1	"	"
$Cu(NO_3)_2$	18.99	1.177	97.3	15	76.0	25	61.5	35	51.3	45	"
"	26.68	1.264	126.2	"	98.8	"	80.9	"	68.6	"	"
"	46.71	1.536	382.9	"	283.8	"	215.3	"	172.2	"	"
$CuSO_4$	6.79	1.055	79.6	15	61.8	25	49.8	35	41.4	45	"
"	12.57	1.115	98.2	"	74.0	"	59.7	"	52.0	"	"
"	17.49	1.163	124.5	"	96.8	"	75.9	"	61.8	"	"
HCl	8.14	1.037	71.0	15	57.9	25	48.3	35	40.1	45	"
"	16.12	1.084	80.0	"	66.5	"	56.4	"	48.1	"	"
"	23.04	1.114	91.8	"	79.9	"	65.9	"	56.4	"	"
$HgCl_2$	0.23	1.023	–	–	58.5	20	46.8	30	38.3	40	"
"	3.55	1.033	76.75	10	59.2	"	46.6	"	38.3	"	"

VISCOSITY OF SOLUTIONS.

Salt.	Percentage by weight of salt in solution.	Density.	μ	t	μ	t	μ	t	μ	t	Authority.
HNO_3	8.37	1.067	66.4	15	54.8	25	45.4	35	37.6	45	Wagner.
"	12.20	1.116	69.5	"	57.3	"	47.9	"	40.7	"	"
"	28.31	1.178	80.3	"	65.5	"	54.9	"	46.2	"	"
H_2SO_4	7.87	1.065	77.8	15	61.0	25	50.0	35	41.7	45	"
"	15.50	1.130	95.1	"	75.0	"	60.5	"	49.8	"	"
"	23.43	1.200	122.7	"	95.5	"	77.5	"	64.3	"	"
KCl	10.23	-	70.0	10	46.1	30	33.1	50	-	-	Sprung.
"	22.21	-	70.0	"	48.6	"	36.4	"	-	-	"
KBr	14.02	-	67.6	10	44.8	30	32.1	50	-	-	"
"	23.16	-	66.2	"	44.7	"	33.2	"	-	-	"
"	34.64	-	66.6	"	47.0	"	35.7	"	-	-	"
KI	8.42	-	69.5	10	44.0	30	31.3	50	-	-	"
"	17.01	-	65.3	"	42.9	"	31.4	"	-	-	"
"	33.03	-	61.8	"	42.9	"	32.4	"	-	-	"
"	45.98	-	63.0	"	45.2	"	35.3	"	-	-	"
"	54.00	-	68.8	"	48.5	"	37.6	"	-	-	"
$KClO_3$	3.51	-	71.7	10	44.7	30	31.5	50	-	-	"
"	5.69	-	-	"	45.0	"	31.4	"	-	-	"
KNO_3	6.32	-	70.8	10	44.6	30	31.8	50	-	-	"
"	12.19	-	68.7	"	44.8	"	32.3	"	-	-	"
"	17.60	-	68.8	"	46.0	"	33.4	"	-	-	"
K_2SO_4	5.17	-	77.4	10	48.6	30	34.3	50	-	-	"
"	9.77	-	81.0	"	52.0	"	36.9	"	-	-	"
K_2CrO_4	11.93	-	75.8	10	62.5	30	41.0	40	-	-	"
"	19.61	-	85.3	"	68.7	"	47.9	"	-	-	"
"	24.26	1.233	97.8	"	74.5	"	54.5	"	-	-	Slotte.
"	32.78	-	109.5	"	88.9	"	62.6	"	-	-	Sprung.
$K_2Cr_2O_7$	4.71	1.032	72.6	10	55.9	20	45.3	30	37.5	40	Slotte.
"	6.97	1.049	73.1	"	56.4	"	45.5	"	37.7	"	"
LiCl	7.76	-	96.1	10	59.7	30	41.2	50	-	-	Sprung.
"	13.91	-	121.3	"	75.9	"	52.6	"	-	-	"
"	26.93	-	229.4	"	142.1	"	98.0	"	-	-	"
$Mg(NO_3)_2$	18.62	1.102	99.8	15	81.3	25	66.5	35	56.2	45	Wagner.
"	34.19	1.200	213.3	"	164.4	"	132.4	"	109.9	"	"
"	39.77	1.430	317.0	"	250.0	"	191.4	"	158.1	"	"
$MgSO_4$	4.98	-	96.2	10	59.0	30	40.9	50	-	-	Sprung.
"	9.50	-	130.9	"	77.7	"	53.0	"	-	-	"
"	19.32	-	302.2	"	166.4	"	106.0	"	-	-	"
$MgCrO_4$	12.31	1.089	111.3	10	84.8	20	67.4	30	55.0	40	Slotte.
"	21.86	1.164	167.1	"	125.3	"	99.0	"	79.4	"	"
"	27.71	1.217	232.2	"	172.6	"	133.9	"	106.6	"	"
$MnCl_2$	8.01	1.096	92.8	15	71.1	25	57.5	35	48.1	45	Wagner.
"	15.65	1.196	130.9	"	104.2	"	84.0	"	68.7	"	"
"	30.33	1.337	256.3	"	193.2	"	155.0	"	123.7	"	"
"	40.13	1.453	537.3	"	393.4	"	300.4	"	246.5	"	"

VISCOSITY OF SOLUTIONS.

Salt.	Percentage by weight of salt in solution.	Density.	μ	t	μ	t	μ	t	μ	t	Authority.
$Mn(NO_3)_2$	18.31	1.148	96.0	15	76.4	25	64.5	35	55.6	45	Wagner.
"	29.60	1.323	167.5	"	126.0	"	104.6	"	88.6	"	"
"	49.31	1.506	396.8	"	301.1	"	221.0	"	188.8	"	"
$MnSO_4$	11.45	1.147	129.4	15	98.6	25	78.3	35	63.4	45	"
"	18.80	1.251	228.6	"	172.2	"	137.1	"	107.4	"	"
"	22.08	1.306	661.8	"	474.3	"	347.9	"	266.8	"	"
NaCl	7.95	–	82.4	10	52.0	30	31.8	50	–	–	Sprung.
"	14.31	–	94.8	"	60.1	"	36.9	"	–	–	"
"	23.22	–	128.3	"	79.4	"	47.4	"	–	–	"
NaBr	9.77	–	75.6	10	48.7	30	34.4	50	–	–	"
"	18.58	–	82.6	"	53.5	"	38.2	"	–	–	"
"	27.27	–	95.9	"	61.7	"	43.8	"	–	–	"
NaI	8.83	–	73.1	10	46.0	30	32.4	50	–	–	"
"	17.15	–	73.8	"	47.4	"	33.7	"	–	–	"
"	35.69	–	86.0	"	55.7	"	40.6	"	–	–	"
"	55.47	–	157.2	"	96.4	"	66.9	"	–	–	"
$NaClO_3$	11.50	–	78.7	10	50.0	30	35.3	50	–	–	"
"	20.59	–	88.9	"	56.8	"	40.4	"	–	–	"
"	33.54	–	121.0	"	75.7	"	53.0	"	–	–	"
$NaNO_3$	7.25	–	75.6	10	47.9	30	33.8	50	–	–	"
"	12.35	–	81.2	"	51.0	"	36.1	"	–	–	"
"	18.20	–	87.0	"	55.9	"	39.3	"	–	–	"
"	31.55	–	121.2	"	76.2	"	53.4	"	–	–	"
Na_2SO_4	4.98	–	96.2	10	59.0	30	40.9	50	–	–	"
"	9.50	–	130.9	"	77.7	"	53.0	"	–	–	"
"	14.03	–	187.9	"	107.4	"	71.1	"	–	–	"
"	19.32	–	302.2	"	166.4	"	106.0	"	–	–	"
Na_2CrO_4	5.76	1.058	85.8	10	66.6	20	53.4	30	43.8	40	Slotte.
"	10.62	1.112	103.3	"	79.3	"	63.5	"	52.3	"	"
"	14.81	1.164	127.5	"	97.1	"	77.3	"	63.0	"	"
NH_4Cl	3.67	–	71.5	10	45.0	30	31.9	50	–	–	Sprung.
"	8.67	–	69.1	"	45.3	"	32.6	"	–	–	"
"	15.68	–	67.3	"	46.2	"	34.0	"	–	–	"
"	23.37	–	67.4	"	47.7	"	36.1	"	–	–	"
NH_4Br	15.97	–	65.2	10	43.2	30	31.5	50	–	–	"
"	25.33	–	62.6	"	43.3	"	32.2	"	–	–	"
"	36.88	–	62.4	"	44.6	"	34.3	"	–	–	"
NH_4NO_3	5.97	–	69.6	10	44.3	30	31.6	50	–	–	"
"	12.19	–	66.8	"	44.3	"	31.9	"	–	–	"
"	27.08	–	67.0	"	47.7	"	34.9	"	–	–	"
"	37.22	–	71.7	"	51.2	"	38.8	"	–	–	"
"	49.83	–	81.1	"	63.3	"	48.9	"	–	–	"
$(NH_4)_2SO_4$	8.10	–	107.9	10	52.3	30	37.0	50	–	–	"
"	15.94	–	120.2	"	60.4	"	43.2	"	–	–	"
"	25.51	–	148.4	"	74.8	"	54.1	"	–	–	"

VISCOSITY OF SOLUTIONS.

Salt.	Percentage by weight of salt in solution.	Density.	μ	t	μ	t	μ	t	μ	t	Authority.
$(NH_4)_2CrO_4$	10.52	1.063	79.3	10	62.4	20	-	-	42.4	40	Slotte.
"	19.75	1.120	88.2	"	70.0	"	57.8	30	48.4	-	"
"	28.04	1.173	101.1	"	80.7	"	60.8	"	56.4	-	"
$(NH_4)_2Cr_2O_7$	6.85	1.039	72.5	10	56.3	20	45.8	30	38.0	40	"
"	13.00	1.078	72.6	"	57.2	"	46.8	"	39.1	"	"
"	19.93	1.126	77.6	"	58.8	"	48.7	"	40.9	"	"
$NiCl_2$	11.45	1.109	90.4	15	70.0	25	57.5	35	48.2	45	Wagner.
"	22.69	1.226	140.2	"	109.7	"	87.8	"	72.7	"	"
"	30.40	1.337	229.5	"	171.8	"	139.2	"	111.9	"	"
$Ni(NO_3)_2$	16.49	1.136	90.7	15	70.1	25	57.4	35	48.9	45	"
"	30.01	1.278	135.6	"	105.9	"	85.5	"	70.7	"	"
"	40.95	1.388	222.6	"	169.7	"	128.2	"	152.4	"	"
$NiSO_4$	10.62	1.092	94.6	15	73.5	25	60.1	35	49.8	45	"
"	18.19	1.198	154.9	"	119.9	"	99.5	"	75.7	"	"
"	25.35	1.314	298.5	"	224.9	"	173.0	"	152.4	"	"
$Pb(NO_3)_2$	17.93	1.179	74.0	15	59.1	25	48.5	35	40.3	45	"
"	32.22	1.362	91.8	"	72.5	"	59.6	"	50.6	"	"
$Sr(NO_3)_2$	10.29	1.088	69.3	15	56.0	25	45.9	35	39.1	45	"
"	21.19	1.124	87.3	"	69.2	"	57.8	"	48.1	"	"
"	32.61	1.307	116.9	"	93.3	"	76.7	"	62.3	"	"
$ZnCl_2$	15.33	1.146	93.6	15	72.7	25	57.8	35	48.2	45	"
"	23.49	1.229	111.5	"	86.6	"	69.8	"	57.5	"	"
"	33.78	1.343	151.7	"	117.9	"	90.0	"	72.6	"	"
$Zn(NO_3)_2$	15.95	1.115	80.7	15	64.3	25	52.6	35	43.8	45	"
"	30.23	1.229	104.7	"	85.7	"	69.5	"	57.7	"	"
"	44.50	1.437	167.9	"	130.6	"	105.4	"	87.9	"	"
$ZnSO_4$	7.12	1.106	97.1	15	79.3	25	62.7	35	51.5	45	"
"	16.64	1.195	156.0	"	118.6	"	94.2	"	73.5	"	"
"	23.09	1.281	232.8	"	177.4	"	135.2	"	108.1	"	"

TABLE 157.

SPECIFIC VISCOSITY.*

Dissolved salt.	Normal solution. Density.	Normal solution. Specific viscosity.	½ normal. Density.	½ normal. Specific viscosity.	¼ normal. Density.	¼ normal. Specific viscosity.	⅛ normal. Density.	⅛ normal. Specific viscosity.	Authority.
Acids: Cl_2O_3 . .	1.0562	1.012	1.0283	1.003	1.0143	1.000	1.0074	0.999	Reyher.
HCl . . .	1.0177	1.067	1.0092	1.034	1.0045	1.017	1.0025	1.009	"
$HClO_3$ . .	1.0485	1.052	1.0244	1.025	1.0126	1.014	1.0064	1.006	"
HNO_3 . .	1.0332	1.027	1.0168	1.011	1.0086	1.005	1.0044	1.003	"
H_2SO_4 . .	1.0303	1.090	1.0154	1.043	1.0074	1.022	1.0035	1.008	Wagner.
Aluminium sulphate	1.0550	1.406	1.0278	1.178	1.0138	1.082	1.0068	1.038	"
Barium chloride . .	1.0884	1.123	1.0441	1.057	1.0226	1.026	1.0114	1.013	"
" nitrate . .	–	–	1.0518	1.044	1.0259	1.021	1.0130	1.008	"
Calcium chloride .	1.0446	1.156	1.0218	1.076	1.0105	1.036	1.0050	1.017	"
" nitrate . .	1.0596	1.117	1.0300	1.053	1.0151	1.022	1.0076	1.008	"
Cadmium chloride .	1.0779	1.134	1.0394	1.063	1.0197	1.031	1.0098	1.020	"
" nitrate .	1.0954	1.165	1.0479	1.074	1.0249	1.038	1.0119	1.018	"
" sulphate.	1.0973	1.348	1.0487	1.157	1.0244	1.078	1.0120	1.033	"
Cobalt chloride . .	1.0571	1.204	1.0286	1.097	1.0144	1.048	1.0058	1.023	"
" nitrate . .	1.0728	1.166	1.0369	1.075	1.0184	1.032	1.0094	1.018	"
" sulphate . .	1.0756	2.354	1.0383	1.160	1.0193	1.077	1.0110	1.040	"
Copper chloride . .	1.0624	1.205	1.0313	1.098	1.0158	1.047	1.0077	1.027	"
" nitrate . .	1.0755	1.179	1.0372	1.080	1.0185	1.040	1.0092	1.018	"
" sulphate .	1.0790	1.358	1.0402	1.160	1.0205	1.080	1.0103	1.038	"
Lead nitrate . . .	1.1380	1.101	0.0699	1.042	1.0351	1.017	1.0175	1.007	"
Lithium chloride .	1.0243	1.142	1.0129	1.066	1.0062	1.031	1.0030	1.012	"
" sulphate .	1.0453	1.290	1.0234	1.137	1.0115	1.065	1.0057	1.032	"
Magnesium chloride	1.1375	1.201	1.0188	1.094	1.0091	1.044	1.0043	1.021	"
" nitrate .	1.0512	1.171	1.0259	1.082	1.0130	1.040	1.0066	1.020	"
" sulphate	1.0584	1.367	1.0297	1.164	1.0152	1.078	1.0076	1.032	"
Manganese chloride	1.0513	1.209	1.0259	1.098	1.0125	1.048	1.0063	1.023	"
" nitrate .	1.0690	1.183	1.0349	1.087	1.0174	1.043	1.0093	1.023	"
" sulphate	1.0728	1.364	1.0365	1.169	1.0179	1.076	1.0087	1.037	"
Nickel chloride . .	1.0591	1.205	1.0308	1.097	1.0144	1.044	1.0067	1.021	"
" nitrate. . .	1.0755	1.180	1.0381	1.084	1.0192	1.042	1.0096	1.019	"
" sulphate . .	1.0773	1.361	1.0391	1.161	1.0198	1.075	1.0017	1.032	"
Potassium chloride .	1.0466	0.987	1.0235	0.987	1.0117	0.990	1.0059	0.993	"
" chromate	1.0935	1.113	1.0475	1.053	1.0241	1.022	1.0121	1.012	"
" nitrate .	1.0605	0.975	1.0305	0.982	1.0161	0.987	1.0075	0.992	"
" sulphate	1.0664	1.105	1.0338	1.049	1.0170	1.021	1.0084	1.008	"
Sodium chloride. .	1.0401	1.097	1.0208	1.047	1.0107	1.024	1.0056	1.013	Reyher.
" bromide. .	1.0786	1.064	1.0396	1.030	1.0190	1.015	1.0100	1.008	"
" chlorate .	1.0710	1.090	1.0359	1.042	1.0180	1.022	1.0092	1.012	"
" nitrate . .	1.0554	1.065	1.0281	1.026	1.0141	1.012	1.0071	1.007	"
Silver nitrate . . .	1.1386	1.058	1.0692	1.020	1.0348	1.006	1.0173	1.000	Wagner.
Strontium chloride .	1.0676	1.141	1.0336	1.067	1.0171	1.034	1.0084	1.014	"
" nitrate .	1.0822	1.115	1.0419	1.049	1.0208	1.024	1.0104	1.011	"
Zinc chloride . . .	1.0509	1.189	1.0302	1.096	1.0152	1.053	1.0077	1.024	"
" nitrate . . .	1.0758	1.164	1.0404	1.086	1.0191	1.039	1.0096	1.019	"
" sulphate. . .	1.0792	1.367	1.0402	1.173	1.0198	1.082	1.0094	1.036	"

* In the case of solutions of salts it has been found (*vide* Arrhennius, Zeits. für Phys. Chem. vol. 1, p. 285) that the specific viscosity can, in many cases, be nearly expressed by the equation $\mu = \mu_1^n$, where μ_1 is the specific viscosity for a normal solution referred to the solvent at the same temperature, and n the number of gramme molecules in the solution under consideration. The same rule may of course be applied to solutions stated in percentages instead of gramme molecules. The table here given has been compiled from the results of Reyher (Zeits. für Phys. Chem. vol. 2, p. 749) and of Wagner (Zeits. für Phys. Chem. vol. 5, p. 31) and illustrates this rule. The numbers are all for 25° C.

VISCOSITY OF GASES AND VAPORS.

The values of μ given in the table are 10^6 times the coefficients of viscosity in C. G. S. units.

Substance.	Temp. °C.	μ	Authority.	Substance.	Temp. °C.	μ	Authority.
Acetone	18.0	78	Puluj.	Carbon dioxide .	12.8	147	Schumann.
Air	0.0	172	Thomlinson.	" " .	100.0	208	"
"	0.0	168	Obermeyer.	Carbon monoxide	0.0	163	Obermeyer.
"	16.7	183	Puluj.	Chlorine . . .	0.0	129	Graham.
Alcohol: Methyl .	66.8	135	Stendel.	" . . .	20.0	147	"
Ethyl .	78.4	142	"	Chloroform . .	17.4	103	Puluj.
Normal propyl	97.4	142	"	Ether	16.0	73	"
Isopropyl	82.8	162	"	Ethyl iodide . .	73.3	216	Stendel.
Normal butyl	116.9	143	"	Methyl " . . .	44.0	232	"
Isobutyl	108.4	144	"	Mercury . . .	270.0	489	Koch.*
Tertiary butyl	82.9	160	"	" . . .	300.0	536	"
Ammonia . . .	0.0	96	Graham.	" . . .	330.0	582	"
" . . .	20.0	108	"	" . . .	360.0	627	"
Benzene	19.0	79	Schumann.	" . . .	390.0	671	"
"	100.0	118	"	Water	0.0	90	Puluj.
Carbon disulphide	16.9	99	Puluj.	"	16.7	97	"
				"	100.0	132	L. Meyer & Schumann.

* The values here given were calculated from Koch's table (Wied. Ann. vol. 19, p. 869) by the formula $\mu = 489 [1 + 746 (t - 270)]$.

COEFFICIENT OF VISCOSITY OF GASES.

The following are a few of the formulæ that have been given for the calculation of the coefficient of viscosity of gases for different temperatures.

Gas.	Value of μ.	Authority.
Air	$\mu_0 (1 + .002751\, t - .00000034\, t^2)$	Holman.
"	$.000172 (1 + 00273\, t)$	O. E. Meyer.
"	$.0001683 (1 + .00274\, t)$	Obermeyer.
Carbon dioxide . .	$\mu_0 (1 + .003725\, t - .00000264\, t^2 + .00000000417\, t^3)$	Holman.
" "	$.0001414 (1 + .00348\, t)$	Obermeyer.
Carbon monoxide .	$.0001630 (1 + .00269\, t)$	"
Ethylene	$.0000966 (1 + .00350\, t)$	"
Ethylene chloride .	$.0000935 (1 + .00381\, t)$	"
Hydrogen	$.0000822 (1 + .00249\, t)$	"
Nitrogen	$.0001635 (1 + .00269\, t)$	"
Nitrous oxide (N_2O)	$.0001408 (1 + .00345\, t)$	"
Oxygen	$.0001873 (1 + .00283\, t)$	"

DIFFUSION OF LIQUIDS AND SOLUTIONS OF SALTS INTO WATER.

The coefficient of diffusion as tabulated below is the constant which multiplied by the rate of change of concentration in any direction gives the rate of flow in that direction in C. G. S. units. Suppose two liquids diffusing into each other, and let ρ be the quantity of one of them per unit volume at a point A, and ρ' the quantity per unit volume at an adjacent point B, and x the distance from A to B. Then if x is small the rate of flow from A towards B is equal to $k(\rho - \rho')/x$, where k is the coefficient of diffusion. Similarly for solutions of salts diffusing into the solvent medium, ρ and ρ' being taken as the quantities of the salt per unit volume. The results indicate that k depends on the absolute density of the solution. Under c will be found the concentration in grammes of the salt per 100 cu. cms. of the solution; under n the number of gramme-molecules of water per gramme-molecule of salt or of acid or other liquid.

Substance.	c	n	$k \times 10^7$	Temp. C. °	Authority.
Ammonia	–	16.0	123	4.5	Scheffer.*
"	–	85.0	123	4.5	"
Ammonium chloride . . .	23	–	135	10.0	Schuhmeister.†
" "	–	61.0	152	17.5	Scheffer
Barium chloride	–	46.0	76	8.0	"
Calcium chloride	–	13.0	83	9.0	"
" "	–	297.0	74	9.0	"
" "	–	384.0	79	9.0	"
" "	10	–	79	10.0	Schuhmeister.
Cobalt chloride	10	–	53	10.0	"
Copper "	10	–	50	10.0	"
Copper sulphate	10	–	24	10.0	"
Hydrochloric acid	–	5.0	267	0.0	Scheffer.
" "	–	9.8	215	0.0	"
" "	–	14.1	195	0.0	"
" "	–	27.1	176	0.0	"
" "	–	129.5	161	0.0	"
" "	–	7.2	309	11.0	"
" "	–	27.6	245	11.0	"
" "	–	69.4	234	11.0	"
" "	–	108.4	213	11.0	"
Lead nitrate	–	136.0	76	12.0	"
" "	–	514.0	82	12.0	"
Lithium chloride	14	–	81	10.0	Schuhmeister.
" bromide	20	–	93	10.0	"
" "	38	–	100	10.0	"
" iodide	17	–	93	10.0	"
Magnesium sulphate . . .	10	–	32	10.0	"
" "	–	45.0	32	5.5	Scheffer.
" "	–	184.0	37	5.5	"
" "	–	30.0	31	10.0	"
" "	–	248.0	39	10.0	"
Potassium chloride	–	32.0	98	7.0	"
" "	–	107.0	106	7.0	"
" "	10	–	127	10.0	Schuhmeister.
" "	30	–	147	10.0	"
" bromide	10	–	131	10.0	"
" "	30	–	144	10.0	"
" iodide	10	–	130	10.0	"
" "	30	–	145	10.0	"
" "	90	–	168	10.0	"
" nitrate	15	–	93	10.0	"
" sulphate	13	–	87	10.0	"
Sodium chloride	10	–	97	10.0	"
" "	30	–	106	10.0	"
" bromide	30	–	99	10.0	"
" iodide	15	–	93	10.0	"
" "	30	–	100	10.0	"
" nitrate	10	–	69	10.0	"
" carbonate	13	–	45	10.0	"
" sulphate	10	–	76	10.0	"
Nitric acid	–	2.9	225	9.0	Scheffer.
" "	–	7.3	234	9.0	"
" "	–	35.0	206	9.0	"
" "	–	426.0	200	9.0	"
Sulphuric acid	–	18.8	124	8.0	"
" "	–	125.0	115	8.5	"
" "	–	686.0	132	9.0	"
" "	–	0.5	150	13.0	"
" "	–	35.0	144	13.0	"

* "Z. für Phys. Chem." 2, p. 390. † "Wien. Akad. Ber." vol. 79, 2. Abth. p. 603.

DIFFUSION OF GASES AND VAPORS.

Coefficients of diffusion of vapors in C. G. S. units. The coefficients are for the temperatures given in the table and a pressure of 76 centimetres of mercury.*

Vapor.	Temp. C. °	k_t for vapor diffusing into hydrogen.	k_t for vapor diffusing into air.	k_t for vapor diffusing into carbon dioxide.
Acids: Formic	0.0	0.5131	0.1315	0.0879
"	65.4	0.7873	0.2035	0.1343
"	84.9	0.8830	0.2244	0.1519
Acetic	0.0	0.4040	0.1061	0.0713
"	65.5	0.6211	0.1578	0.1048
"	98.5	0.7481	0.1965	0.1321
Isovaleric	0.0	0.2118	0.0555	0.0375
"	98.0	0.3934	0.1031	0.0696
Alcohols: Methyl	0.0	0.5001	0.1325	0.0880
"	25.6	0.6015	0.1620	0.1046
"	49.6	0.6738	0.1809	0.1234
Ethyl	0.0	0.3806	0.0994	0.0693
"	40.4	0.5030	0.1372	0.0898
"	66.9	0.5430	0.1475	0.1026
Propyl	0.0	0.3153	0.0803	0.0577
"	66.9	0.4832	0.1237	0.0901
"	83.5	0.5434	0.1379	0.0976
Butyl	0.0	0.2716	0.0681	0.0476
"	99.0	0.5045	0.1265	0.0884
Amyl	0.0	0.2351	0.0589	0.0422
"	99.1	0.4362	0.1094	0.0784
Hexyl	0.0	0.1998	0.0499	0.0351
"	99.0	0.3712	0.0927	0.0651
Benzene	0.0	0.2940	0.0751	0.0527
"	19.9	0.3409	0.0877	0.0609
"	45.0	0.3993	0.1011	0.0715
Carbon disulphide	0.0	0.3690	0.0883	0.0629
" "	19.9	0.4255	0.1015	0.0726
" "	32.8	0.4626	0.1120	0.0789
Esters: Methyl acetate	0.0	0.3357	0.0852	0.0572
" "	20.3	0.3928	0.1013	0.0679
Ethyl "	0.0	0.2373	0.0630	0.0450
" "	46.1	0.3729	0.0970	0.0666
Methyl butyrate	0.0	0.2422	0.0640	0.0438
" "	92.1	0.4308	0.1139	0.0809
Ethyl "	0.0	0.2238	0.0573	0.0406
" "	96.5	0.4112	0.1064	0.0756
" valerate	0.0	0.2050	0.0505	0.0366
" "	97.6	0.3784	0.0932	0.0676
Ether	0.0	0.2960	0.0775	0.0552
"	19.9	0.3410	0.0893	0.0636
Water	0.0	0.6870	0.1980	0.1310
"	49.5	1.0000	0.2827	0.1811
"	92.4	1.1794	0.3451	0.2384

* Taken from Winkelmann's papers (Wied. Ann. vols. 22, 23, and 26). The coefficients for 0° were calculated by Winkelmann on the assumption that the rate of diffusion is proportional to the absolute temperature. According to the investigations of Loschmidt and of Obermeyer the coefficient of diffusion of a gas, or vapor, at 0° C. and a pressure of 76 centimetres of mercury may be calculated from the observed coefficient at another temperature and pressure by the formula $k_0 = k_T \left(\frac{T_0}{T}\right)^n \frac{76}{p}$, where T is temperature absolute and p the pressure of the gas. The exponent n is found to be about 1.75 for the permanent gases and about 2 for condensible gases. The following are examples: Air — CO_2, $n = 1.968$; CO_2 — N_2O, $n = 2.05$; CO_2 — H, $n = 1.742$; CO — O, $n = 1.785$; H — O, $n = 1.755$; O — N, $n = 1.792$. Winkelmann's results, as given in the above table, seem to give about 2 for vapors diffusing into air, hydrogen or carbon dioxide.

COEFFICIENTS OF DIFFUSION FOR VARIOUS GASES AND VAPORS.*

Gas or vapor diffusing.	Gas or vapor diffused into.	Temp. C.°	Coefficient of diffusion.	Authority.
Air	Carbon dioxide . .	0	0.1343	Obermayer.
"	Oxygen . . .	0	0.1775	"
Carbon dioxide . . .	Air	0	0.1423	Loschmidt.
" "	"	0	0.1360	Waitz.
" "	Carbon monoxide .	0	0.1405	Loschmidt.
" "	" " . .	0	0.1314	Obermayer.
" "	Ethylene . . .	0	0.1006	"
" "	Hydrogen . . .	0	0.5437	"
" "	Methane . . .	0	0.1465	"
" "	Nitrous oxide . .	0	0.0983	Loschmidt.
" "	Oxygen . . .	0	0.1802	"
Carbon disulphide . .	Air	0	0.0995	Stefan.
Carbon monoxide . .	Carbon dioxide . .	0	0.1314	Obermayer.
" " . .	Ethylene . . .	0	0.1164	"
" " . .	Hydrogen . . .	0	0.6422	Loschmidt.
" " . .	Oxygen . . .	0	0.1802	"
" " . .	" . . .	0	0.1872	Obermayer.
Ether	Air	0	0.0827	Stefan.
"	Hydrogen . . .	0	0.3054	"
Hydrogen	Air	0	0.6340	Obermayer.
"	Carbon dioxide . .	0	0.5384	"
"	" monoxide .	0	0.6488	"
"	Ethane	0	0.4593	"
"	Ethylene . . .	0	0.4863	"
"	Methane . . .	0	0.6254	"
"	Nitrous oxide . .	0	0.5347	"
"	Oxygen . . .	0	0.6788	"
Nitrogen	Oxygen . . .	0	0.1787	"
Oxygen	Carbon dioxide . .	0	0.1357	"
"	Hydrogen . . .	0	0.7217	Loschmidt.
" . .	Nitrogen . . .	0	0.1710	Obermayer.
Sulphur dioxide . .	Hydrogen . . .	0	0.4828	Loschmidt.
Water	Air	8	0.2390	Guglielmo.
"	"	18	0.2475	"
"	Hydrogen . . .	18	0.8710	"

* Compiled for the most part from a similar table in Landolt & Boernstein's "Phys. Chem. Tab."

OSMOSE.

The following table given by H. de Vries* illustrates an apparent relation between the isotonic coefficient † of solutions and the corresponding lowering of the freezing-point and the vapor pressure. The freezing-points are taken on the authority of Raoult, and the vapor pressures on the authority of Tammann.‡

Substance.	Formula.	Isotonic coefficient × 100.	Molecular lowering of the freezing point × 100.	Molecular lowering of the vapor pressure × 1000.
Glycerine	$C_3H_8O_3$	178	171	–
Cane sugar	$C_{12}H_{22}O_{11}$	188	185	–
Tartaric acid	$C_4H_6O_6$	202	195	188
Magnesium sulphate	$MgSO_4$	196	192	156
Potassium nitrate	KNO_3	300	308	267
Sodium nitrate	$NaNO_3$	300	337	296
Potassium chloride	KCl	287	336	313
Sodium chloride	$NaCl$	305	351	330
Ammonium chloride	NH_4Cl	300	348	313
Potassium acetate	$KC_2H_3O_2$	300	345	331
Potassium oxalate	$K_2C_2O_4$	393	450	372
Potassium sulphate	K_2SO_4	392	390	351
Magnesium chloride	$MgCl_2$	433	488	513
Calcium chloride	$CaCl_2$	433	466	517

TABLE 164.

OSMOTIC PRESSURE.

The following numbers give the result of Pfeffer's § measurement of the magnitude of the osmotic pressure for a one per cent sugar solution. The result was found to agree with that of an equal molecular solution of hydrogen. The value for the hydrogen solution is given in the third column of the table.

Temperature C.	Osmotic pressure in atmospheres.	$0.649(1 + .00367t)$
6.8	0.664	0.665
13.7	0.691	0.681
14.2	0.671	0.682
15.5	0.684	0.686
22.0	0.721	0.701
32.0	0.716	0.725
36.0	0.746	0.735

* "Zeits. für Phys. Chem." vol. 2, p. 427.

† The isotonic coefficient is the relative value of the molecular attraction of the different salts for water or the relative value of the osmotic pressures for normal solutions. In the above table the coefficient for KNO_3 was taken as 3 arbitrarily and the others compared with it. The concentrations of different salts which give equal osmotic pressures are called by Tammann and others isosmotic concentrations; they are sometimes called isotonic concentrations. The reciprocals of the numbers of molecules in the isotonic concentrations are called by De Vries the isotonic coefficients.

‡ See also Tammann, "Wied. Ann." vol. 34, p. 315.

§ Winkelmann's "Handbuch der Physik," vol. 1, p. 632.

PRESSURE OF AQUEOUS VAPOR, ACCORDING TO REGNAULT.

The last four columns were calculated from the data given in the second column and the density of mercury.

Temp. ° Cent.	Pressure: mm. of mercury.	Grammes per sq. centimetre.	Pounds per sq. inch.	Pressure: inches of mercury.	Pressure: atmospheres.	Temp. ° Fahr.	Temp. ° Cent.	Pressure: mm. of mercury.	Grammes per sq. centimetre.	Pounds per sq. inch.	Pressure: inches of mercury.	Pressure: atmospheres.	Temp. ° Fahr.
0	4.60	6.254	0.0890	0.181	0.0061	**32.0**	**40**	54.91	74.653	1.061	2.162	0.072	**104.0**
1	4.94	6.716	.0955	.194	.0065	33.8	41	57.91	78.678	1.121	2.280	.076	105.8
2	5.30	7.206	.1025	.209	.0070	35.6	42	61.01	82.947	1.216	2.404	.080	107.6
3	5.69	7.736	.1100	.224	.0075	37.4	43	64.35	87.488	1.244	2.533	.085	109.4
4	6.10	8.291	.1180	.240	.0080	39.2	44	67.79	92.165	1.312	2.669	.089	111.2
5	6.53	8.878	0.1263	0.257	0.0086	**41.0**	**45**	71.39	97.059	1.381	2.811	0.094	**113.0**
6	7.00	9.517	.1354	.276	.0092	42.8	46	75.16	102.184	1.454	2.959	.099	114.8
7	7.49	10.183	.1452	.295	.0099	44.6	47	79.09	107.528	1.530	3.114	.104	116.6
8	8.02	10.904	.1551	.316	.0107	46.4	48	83.20	113.115	1.609	3.276	.109	118.4
9	8.57	11.651	.1657	.338	.0114	48.2	49	87.50	118.962	1.692	3.444	.115	120.2
10	9.17	12.467	0.1773	0.361	0.012	**50.0**	**50**	91.98	125.05	1.78	3.62	0.121	**122.0**
11	9.79	13.310	.1893	.386	.013	51.8	51	96.66	131.42	1.87	3.81	.127	123.8
12	10.46	14.207	.2023	.412	.014	53.6	52	101.54	138.04	1.96	4.00	.134	125.6
13	11.16	15.173	.2158	.439	.015	55.4	53	106.64	144.98	2.06	4.20	.140	127.4
14	11.91	16.192	.2303	.469	.016	57.2	54	111.95	152.20	2.17	4.41	.147	129.2
15	12.70	17.266	0.2456	0.500	0.017	**59.0**	**55**	117.48	159.72	2.27	4.63	0.155	**131.0**
16	13.54	18.408	.2618	.533	.018	60.8	56	123.24	167.55	2.39	4.85	.163	132.8
17	14.42	19.605	.2789	.568	.019	62.6	57	129.25	175.72	2.50	5.09	.170	134.6
18	15.36	20.883	.2970	.605	.020	64.4	58	135.51	184.23	2.62	5.33	.178	136.4
19	16.35	22.229	.3162	.644	.022	66.2	59	142.02	193.08	2.75	5.59	.187	138.2
20	17.39	23.643	0.3363	0.685	0.023	**68.0**	**60**	148.79	202.29	2.88	5.86	0.196	**140.0**
21	18.50	25.152	.3577	.728	.024	69.8	61	155.84	211.87	3.01	6.14	.205	141.8
22	19.66	26.729	.3802	.774	.026	71.6	62	163.17	221.84	3.16	6.42	.215	143.6
23	20.89	28.401	.4040	.822	.028	73.4	63	170.79	232.20	3.30	6.72	.225	145.4
24	22.18	30.155	.4289	.873	.029	75.2	64	178.71	242.97	3.46	7.04	.235	147.2
25	23.55	32.018	0.4554	0.927	0.031	**77.0**	**65**	186.95	254.17	3.62	7.36	0.246	**149.0**
26	24.99	33.975	.4833	.984	.033	78.8	66	195.50	265.79	3.78	7.70	.257	150.8
27	26.51	36.042	.5126	1.044	.034	80.6	67	204.38	277.87	3.95	8.05	.267	152.6
28	28.10	38.204	.5434	.106	.037	82.4	68	213.60	290.40	4.13	8.41	.281	154.4
29	29.78	40.488	.5759	.172	.039	84.2	69	223.17	303.41	4.32	8.79	.494	156.2
30	31.55	42.894	0.6101	1.242	0.042	**86.0**	**70**	233.09	316.90	4.51	9.18	0.306	**158.0**
31	33.41	45.423	.6461	.315	.044	87.8	71	243.39	330.90	4.71	9.58	.320	159.8
32	35.36	48.074	.6838	.392	.047	89.6	72	254.07	345.42	4.91	10.00	.334	161.6
33	37.41	59.861	.7234	.473	.049	91.4	73	265.15	360.49	5.12	10.44	.349	163.4
34	39.57	53.798	.7655	.558	.052	93.2	74	276.62	376.08	5.35	10.89	.364	165.2
35	41.83	56.870	0.810	1.647	0.055	**95.0**	**75**	288.52	392.26	5.58	11.36	0.380	**167.0**
36	44.20	60.093	.855	.740	.058	96.8	76	300.84	409.01	5.82	11.84	.396	168.8
37	46.69	63.478	.903	.838	.061	98.6	77	313.60	426.36	6.06	12.35	.414	170.6
38	49.30	67.026	.954	.941	.065	100.4	78	326.81	444.32	6.32	12.87	.430	172.4
39	52.04	70.752	1.007	2.049	.068	102.2	79	340.49	462.92	6.58	13.40	.448	174.2

TABLE 165.

PRESSURE OF AQUEOUS VAPOR, ACCORDING TO REGNAULT.

Temp. ° Cent.	Pressure: mm. of mercury.	Grammes per sq. centimetre.	Pounds per sq. inch.	Pressure: inches of mercury.	Pressure: atmospheres.	Temp. ° Fahr.	Temp. ° Cent.	Pressure: mm. of mercury.	Grammes per sq. centimetres.	Pounds per sq. inch.	Pressure: inches of mercury.	Pressure: atmospheres.	Temp. ° Fahr.
80	354.64	482.15	6.85	13.96	0.446	**176.0**	**120**	1491.28	2027.48	28.85	58.71	1.962	**248.0**
81	369.29	502.07	7.14	14.54	.486	177.8	121	1539.25	2092.70	29.78	60.61	2.025	249.8
82	384.44	522.67	7.44	15.14	.506	179.6	122	1588.47	2159.62	30.73	62.54	.091	251.6
83	400.10	543.96	7.74	15.75	.526	181.4	123	1638.96	2228.26	31.70	64.53	.157	253.4
84	416.30	565.99	8.05	16.39	.548	183.2	124	1690.76	2298.69	32.70	66.56	.225	255.2
85	433.04	588.74	8.37	17.05	0.570	**185.0**	**125**	1743.88	2370.91	33.72	68.66	2.295	**257.0**
86	450.34	612.26	8.71	17.73	.593	186.8	126	1798.35	2444.96	34.78	70.80	.366	258.8
87	468.22	636.57	9.05	18.43	.616	188.6	127	1854.20	2520.89	35.86	73.00	.430	260.6
88	486.69	661.68	9.41	19.16	.640	180.4	128	1911.47	2598.76	36.97	75.25	.515	262.4
89	505.76	687.61	9.78	19.91	.665	192.2	129	1970.15	2678.54	38.11	77.57	.592	264.2
90	525.45	714.38	10.16	20.69	0.691	**194.0**	**130**	2030.28	2760.29	39.26	79.93	2.671	**266.0**
91	545.78	740.31	10.56	21.49	.719	195.8	131	2091.94	2844.12	40.47	82.36	.753	267.8
92	566.76	770.54	10.95	22.31	.746	197.6	132	2155.03	2929.89	41.68	84.84	.836	269.6
93	588.41	799.98	11.38	23.17	.774	199.4	133	2219.69	3017.80	42.93	87.39	.921	271.4
94	610.74	830.34	11.81	24.04	.804	201.2	134	2285.92	3107.85	44.21	89.99	3.008	273.2
95	633.78	861.66	12.26	24.95	0.834	**203.0**	**135**	2353.73	3200.04	45.52	92.67	3.097	**275.0**
96	657.54	893.97	12.71	25.89	.865	204.8	136	2423.16	3294.43	46.87	95.39	.188	276.8
97	682.03	927.26	13.19	26.85	.897	206.6	137	2494.23	3391.06	48.24	98.19	.282	278.6
98	707.28	961.59	13.68	27.85	.931	208.4	138	2567.00	3489.99	49.65	101.06	.378	280.4
99	733.31	996.98	14.18	28.87	.965	210.2	139	2641.44	3591.29	51.06	103.99	.476	282.2
100	760.00	1033.26	14.70	29.92	1.000	**212.0**	**140**	2717.63	3694.78	52.55	106.99	3.576	**284.0**
101	787.59	1070.78	15.23	31.01	.036	213.8	141	2795.57	3800.75	54.07	110.06	.678	285.8
102	816.01	1109.41	15.79	32.13	.074	215.6	142	2875.30	3909.14	55.60	113.20	.783	287.6
103	845.28	1149.21	16.35	33.28	.112	217.4	143	2956.86	4020.03	57.16	116.41	.890	289.4
104	875.41	1190.17	16.94	34.46	.152	219.2	144	3040.26	4133.42	58.79	119.69	4.000	291.2
105	906.41	1232.32	17.53	35.69	1.193	**221.0**	**145**	3125.55	4249.37	60.44	123.05	4.113	**293.0**
106	938.31	1275.69	18.15	36.94	.235	222.8	146	3212.74	4367.91	62.13	126.48	.227	294.8
107	971.14	1320.32	18.78	38.23	.278	224.6	147	3301.87	4489.09	63.86	129.99	.344	296.6
108	1004.91	1366.24	19.44	39.56	.322	226.4	148	3392.98	4612.96	65.62	133.58	.464	298.4
109	1039.65	1413.47	20.11	40.93	.368	228.2	149	3486.09	4739.55	67.41	137.25	.587	300.2
110	1075.37	1462.03	20.80	42.34	1.415	**230.0**	**150**	3581.2	4868.9	69.26	141.0	4.712	**302.0**
111	1112.09	1511.97	21.51	43.78	.463	231.8	151	3678.4	5001.1	71.14	144.8	.840	303.8
112	1149.83	1563.26	22.24	45.25	.513	233.6	152	3777.7	5136.1	73.06	148.7	.971	305.6
113	1188.61	1615.99	22.99	46.80	.564	235.4	153	3879.2	5275.0	75.02	152.7	5.104	307.4
114	1228.47	1670.18	23.76	48.37	.616	237.2	154	3982.8	5414.8	77.03	156.8	.240	309.2
115	1269.41	1725.84	24.55	49.98	1.670	**239.0**	**155**	4088.6	5558.6	79.07	161.0	5.380	**311.0**
116	1311.47	1783.02	25.37	51.63	.726	240.8	156	4196.6	5705.5	81.22	165.2	.522	312.8
117	1354.66	1841.74	26.20	53.34	.782	242.6	157	4306.9	5855.5	83.29	169.6	.667	314.6
118	1399.02	1902.05	27.06	55.08	.841	244.4	158	4419.5	6008.5	85.47	174.0	.815	316.4
119	1444.55	1963.95	27.94	56.87	.901	246.2	159	4534.4	6164.7	87.69	178.5	.966	318.2

PRESSURE OF AQUEOUS VAPOR, ACCORDING TO REGNAULT.

Temp. ° Cent.	Pressure: mm. of mercury.	Grammes per sq. centimetre.	Pounds per sq. inch.	Pressure: inches of mercury.	Pressure: atmospheres.	Temp. ° Fahr.	Temp. ° Cent.	Pressure: mm. of mercury.	Grammes per sq. centimetre.	Pounds per sq. inch.	Pressure: inches of mercury.	Pressure: atmospheres.	Temp. ° Fahr.
160	4651.6	6324.2	89.96	183.1	6.120	**320.0**	**195**	10519.6	14302.7	203.43	414.1	13.842	**383.0**
161	4771.3	6486.8	92.27	187.9	6.278	321.8	196	10746.0	14609.8	207.81	423.1	14.139	384.8
162	4893.4	6652.8	94.63	192.7	6.439	323.6	197	10975.0	14921.2	212.25	432.1	14.441	386.6
163	5017.9	6822.2	97.04	197.6	6.603	325.4	198	11209.8	15240.4	216.77	441.3	14.749	388.4
164	5145.0	6994.9	99.50	202.6	6.770	327.2	199	11447.5	15563.5	221.37	450.7	15.062	390.2
165	5274.5	7171.1	102.01	207.7	6.940	**329.0**	**200**	11689.0	15891.9	226.04	460.1	15.380	**392.0**
166	5406.7	7350.7	104.56	212.9	7.114	330.8	201	11934.4	16225.5	230.79	469.8	15.703	393.8
167	5541.4	7533.9	107.18	218.2	7.291	332.6	202	12183.7	16564.7	235.61	479.7	16.031	395.6
168	5678.8	7720.7	109.84	223.6	7.472	334.4	203	12437.0	16908.8	240.54	489.6	16.364	397.4
169	5818.9	7911.1	112.53	229.1	7.656	336.2	204	12694.3	17257.3	245.49	499.8	16.703	399.2
170	5961.7	8105.2	115.29	234.1	7.844	**338.0**	**205**	12955.7	17614.0	250.53	510.1	17.047	**401.0**
171	6107.2	8303.1	118.11	240.4	8.036	339.8	206	13221.1	17974.9	255.67	520.5	17.396	402.8
172	6255.5	8504.7	120.98	246.3	8.231	341.6	207	13490.8	18341.5	260.88	531.2	17.751	404.6
173	6406.6	8710.2	123.90	252.2	8.430	343.4	208	13764.5	18713.7	266.18	541.9	18.111	406.4
174	6560.6	8919.5	126.87	258.3	8.632	345.2	209	14042.5	19091.6	271.55	552.9	18.477	408.2
175	6717.4	9132.8	129.91	264.5	8.839	**347.0**	**210**	14324.8	19475.4	277.01	564.1	18.848	**410.0**
176	6877.2	9350.0	133.00	270.8	9.049	348.8	211	14611.3	19864.9	282.58	575.3	19.226	411.8
177	7040.0	9571.3	136.15	277.2	9.263	350.6	212	14902.2	20260.5	288.21	586.7	19.608	413.6
178	7205.7	9796.6	139.35	283.7	9.481	352.4	213	15197.5	20661.9	293.92	598.3	19.997	415.4
179	7374.5	10026.1	142.62	290.3	9.703	354.2	214	15497.2	21069.3	299.72	610.2	20.391	417.2
180	7546.4	10259.7	145.93	297.1	9.929	**356.0**	**215**	15801.3	21482.8	305.57	622.1	20.791	**419.0**
181	7721.4	10497.7	149.32	304.0	10.150	357.8	216	16109.9	21902.4	311.57	634.2	21.197	420.8
182	7899.5	10739.9	152.77	311.0	10.394	359.6	217	16423.2	22328.3	317.62	646.6	21.690	422.6
183	8080.8	10986.4	156.32	318.1	10.633	361.4	218	16740.9	22760.3	323.78	659.1	22.027	424.4
184	8265.4	11237.3	159.84	325.4	10.876	363.2	219	17063.3	23198.6	330.01	671.8	22.452	426.2
185	8453.2	11490.0	163.47	332.3	11.123	**365.0**	**220**	17390.4	23643.2	336.30	684.7	22.882	**428.0**
186	8644.4	11752.5	167.17	340.3	11.374	366.8	221	17722.1	24094.3	342.70	697.7	23.319	429.8
187	8838.8	12016.9	170.94	348.0	11.630	368.6	222	18058.6	24551.8	349.21	711.0	23.761	431.6
188	9036.7	12285.9	174.76	355.8	11.885	370.4	223	18399.9	25015.8	355.81	724.4	24.210	433.4
189	9238.0	12559.6	178.65	363.7	12.155	372.2	224	18746.1	25486.4	362.50	738.0	24.666	435.2
190	9442.7	12837.9	182.61	371.8	12.425	**374.0**	**225**	19097.0	25963.5	369.29	751.9	25.128	**437.0**
191	9650.9	13121.0	186.63	380.0	12.699	375.8	226	19452.9	26447.4	376.17	765.8	25.596	438.8
192	9862.7	13408.9	190.72	388.3	12.977	377.6	227	19813.8	26938.0	383.15	780.9	26.071	440.6
193	10078.0	13701.7	194.88	396.8	13.261	379.4	228	20179.6	27435.4	390.22	794.5	26.552	442.4
194	10297.0	13999.4	199.13	405.4	13.549	381.2	229	20550.5	27939.6	397.40	809.0	27.040	444.2

TABLE 166.

PRESSURE OF AQUEOUS VAPOR, ACCORDING TO BROCH.*

Temp. °C.	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8
−28	0.46	0.45	0.44	0.43	0.43	0.42	0.41	0.40	0.40	0.39
−26	0.55	0.54	0.53	0.52	0.51	0.50	0.50	0.49	0.48	0.47
−24	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.58	0.57	0.56
−22	0.79	0.78	0.77	0.75	0.74	0.73	0.71	0.70	0.69	0.68
−20	0.94	0.93	0.91	0.90	0.88	0.87	0.85	0.84	0.82	0.81
−18	1.12	1.10	1.08	1.06	1.05	1.03	1.01	0.99	0.98	0.96
−16	1.32	1.30	1.28	1.26	1.24	1.22	1.20	1.18	1.16	1.14
−14	1.56	1.54	1.51	1.49	1.46	1.44	1.42	1.39	1.37	1.35
−12	1.84	1.81	1.78	1.75	1.72	1.69	1.67	1.64	1.61	1.59
−10	2.15	2.12	2.08	2.05	2.02	1.99	1.96	1.93	1.90	1.87
−8	2.51	2.48	2.44	2.40	2.36	2.33	2.29	2.26	2.22	2.19
−6	2.93	2.89	2.84	2.80	2.76	2.72	2.67	2.63	2.59	2.55
−4	3.41	3.36	3.31	3.26	3.21	3.16	3.11	3.07	3.03	2.98
−2	3.95	3.89	3.84	3.78	3.72	3.67	3.62	3.56	3.51	3.46
−0	4.57	4.50	4.44	4.37	4.31	4.25	4.19	4.13	4.07	4.01
+0	4.57	4.64	4.70	4.77	4.84	4.91	4.98	5.05	5.12	5.20
2	5.27	5.35	5.42	5.50	5.58	5.66	5.74	5.82	5.90	5.99
4	6.07	6.15	6.24	6.33	6.42	6.51	6.60	6.69	6.78	6.88
6	6.97	7.07	7.17	7.26	7.36	7.47	7.57	7.67	7.78	7.88
8	7.99	8.10	8.21	8.32	8.43	8.55	8.66	8.78	8.90	9.02
10	9.14	9.26	9.39	9.51	9.64	9.77	9.90	10.03	10.16	10.30
12	10.43	10.57	10.71	20.85	10.99	11.14	11.28	11.43	11.58	11.73
14	11.88	12.04	12.19	12.35	12.51	12.67	12.84	13.00	13.17	13.34
16	13.51	13.68	13.86	14.04	14.21	14.40	14.58	14.76	14.95	15.14
18	15.33	15.52	15.72	15.92	16.12	16.32	16.52	16.73	16.94	17.15
20	17.36	17.58	17.80	18.02	18.24	18.47	18.69	18.92	19.16	19.39
22	19.63	19.87	20.11	20.36	20.61	20.86	21.11	21.37	21.63	21.89
24	22.15	22.42	22.69	22.96	23.24	23.52	23.80	24.08	24.37	24.66
26	24.96	25.25	25.55	25.86	26.16	26.47	26.78	27.10	27.42	27.74
28	28.07	28.39	28.73	29.06	29.40	29.74	30.09	30.44	30.79	31.15
30	31.51	31.87	32.24	32.61	32.99	33.37	33.75	34.14	34.53	34.92
32	35.32	35.72	36.13	36.54	36.95	37.37	37.79	38.22	38.65	39.08
34	39.52	39.97	40.41	40.87	41.32	41.78	42.25	42.72	43.19	43.67
36	44.16	44.65	45.14	45.64	46.14	46.65	47.16	47.68	48.20	48.73
38	49.26	49.80	50.34	50.89	51.44	52.00	52.56	53.13	53.70	54.28
40	54.87	55.46	56.05	56.65	57.26	57.87	58.49	59.11	59.74	60.38
42	61.02	61.66	62.32	62.98	63.64	64.31	64.99	65.67	66.36	67.05
44	67.76	68.47	69.18	69.90	70.63	71.36	72.10	72.85	73.60	74.36
46	75.13	75.91	76.69	77.47	78.27	79.07	79.88	80.70	81.52	82.35
48	83.19	84.03	84.89	85.75	86.61	87.49	88.37	89.26	90.16	91.06
50	91.98	92.90	93.83	94.77	95.71	96.66	97.63	98.60	99.57	100.56
52	101.55	102.56	103.57	104.59	105.62	106.65	107.70	108.76	109.82	110.89
54	111.97	113.06	114.16	115.27	116.39	117.52	118.65	119.80	120.95	122.12
56	123.29	124.48	125.67	126.87	128.09	129.31	130.54	131.79	133.04	134.30
58	135.58	136.86	138.15	139.46	140.77	142.10	143.43	144.78	146.14	147.51
60	148.88	150.27	151.68	153.09	154.51	155.95	157.39	158.85	160.32	161.80
62	163.29	164.79	166.31	167.83	169.37	170.92	172.49	174.06	175.65	177.25
64	178.86	180.48	182.12	183.77	185.43	187.10	188.79	190.49	192.20	193.93
66	195.67	197.42	199.18	200.96	202.75	204.56	206.38	208.21	210.06	211.92
68	213.79	215.68	217.58	219.50	221.43	223.37	225.33	227.30	229.29	231.29

* This table is based on Regnault's experiments, the numbers being taken from Broch's reduction of the observations (Trav. et Mém. du Bur. Int. des Poids et Més. tom. 1). The numbers differ very slightly from those of Regnault (see Table 165). The direct measurements of Marvin given in Table 169 show that the numbers in this table are high for temperature below zero centigrade.

TABLE 166.

PRESSURE OF AQUEOUS VAPOR, ACCORDING TO BROCH.

Temp. °C.	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8
70	233.31	235.34	237.39	239.45	241.52	243.62	245.72	247.85	249.98	252.14
72	254.30	256.49	258.69	260.91	263.14	265.38	267.65	269.93	272.23	274.54
74	276.87	279.21	281.58	283.95	286.35	288.76	291.19	293.64	296.11	298.59
76	301.09	303.60	306.14	308.69	311.26	313.85	316.45	319.07	321.72	324.38
78	327.05	329.75	332.47	335.20	337.95	340.73	343.52	346.33	349.16	352.01
80	354.87	357.76	360.67	363.59	366.54	369.51	372.49	375.50	378.53	381.58
82	384.64	387.73	390.84	393.97	397.12	400.29	403.49	406.70	409.94	413.19
84	416.47	419.77	423.09	426.44	429.81	433.19	436.60	440.04	443.49	446.97
86	450.47	454.00	457.54	461.11	464.71	468.32	471.96	475.63	479.32	483.03
88	486.76	490.52	494.31	498.12	501.95	505.81	509.69	513.60	517.53	521.48
90	525.47	529.48	533.51	537.57	541.65	545.77	549.90	554.07	558.26	562.47
92	566.71	570.98	575.28	579.61	583.96	588.33	592.74	597.17	601.64	606.13
94	610.64	615.19	619.76	624.37	629.00	633.66	638.35	643.06	647.81	652.59
96	657.40	662.23	667.10	672.00	676.00	681.88	686.87	691.89	696.93	702.02
98	707.13	712.27	717.44	722.65	727.89	733.16	738.46	743.80	749.17	754.57
100	760.00	765.47	770.97	776.50	782.07	787.67	-	-	-	-

TABLE 167.

WEIGHT IN GRAINS OF THE AQUEOUS VAPOR CONTAINED IN A CUBIC FOOT OF SATURATED AIR.*

Temp. °F.	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
−10	0.356	0.340	0.324	0.309	0.294	0.280	0.267	0.254	0.242	0.230
−0	0.564	0.540	0.516	0.493	0.471	0.450	0.430	0.411	0.391	0.373
+0	0.564	0.590	0.617	0.645	0.674	0.705	0.735	0.767	0.801	0.837
10	0.873	0.910	0.950	0.991	1.033	1.077	1.122	1.169	1.217	1.268
20	1.321	1.374	1.430	1.488	1.549	1.611	1.675	1.743	1.812	1.882
30	1.956	2.034	2.113	2.194	2.279	2.366	2.457	2.550	2.646	2.746
40	2.849	2.955	3.064	3.177	3.294	3.414	3.539	3.667	3.800	3.936
50	4.076	4.222	4.372	4.526	4.685	4.849	5.016	5.191	5.370	5.555
60	5.745	5.941	6.142	6.349	6.563	6.782	7.009	7.241	7.480	7.726
70	7.980	8.240	8.508	8.782	9.066	9.356	9.655	9.962	10.277	10.601
80	10.934	11.275	11.626	11.987	12.356	12.736	13.127	13.526	13.937	14.359
90	14.790	15.234	15.689	16.155	16.634	17.124	17.626	18.142	18.671	19.212
100	19.766	20.335	20.917	21.514	22.125	22.750	23.392	24.048	24.720	25.408
110	26.112	26.832	27.570	28.325	29.096	29.887	-	-	-	-

TABLE 168.

WEIGHT IN GRAMMES OF THE AQUEOUS VAPOR CONTAINED IN A CUBIC METRE OF SATURATED AIR.

Temp. °C.	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
−20	1.078	0.992	0.913	0.839	0.770	0.706	0.647	0.593	0.542	0.496
−10	2.363	2.192	2.032	1.882	1.742	1.611	1.489	1.375	1.269	1.170
−0	4.835	4.513	4.211	3.926	3.659	3.407	3.171	2.949	2.741	2.546
+0	4.835	5.176	5.538	5.922	6.330	6.761	7.219	7.703	8.215	8.757
10	9.330	9.935	10.574	11.249	11.961	12.712	13.505	14.339	15.218	16.144
20	17.118	18.143	19.222	20.355	21.546	22.796	24.109	25.487	26.933	28.450
30	30.039	31.704	33.449	35.275	37.187	39.187	41.279	43.465	45.751	48.138

* See "Smithsonian Meteorological Tables," pp. 132–133.

TABLE 169.

PRESSURE OF AQUEOUS VAPOR AT LOW TEMPERATURE.*

Pressures are given in inches and millimetres of mercury, temperatures in degrees Fahrenheit and degrees Centigrade.

(a) Pressures in inches of mercury; temperatures in degrees Fahrenheit.

Temp. F.	0°.0	1°.0	2°.0	3°.0	4°.0	5°.0	6°.0	7°.0	8°.0	9°.0
—50°	0.0021	0.0019	0.0018	0.0017	0.0016	0.0015	0.0013	0.0013	0.0012	0.0011
—40	.0039	.0037	.0035	.0033	.0031	.0029	.0027	.0026	.0024	.0022
—30	.0069	.0065	.0061	.0057	.0054	.0051	.0048	.0046	.0044	.0041
—20	.0126	.0119	.0112	.0106	.0100	.0094	.0089	.0083	.0078	.0074
—10	.0222	.0210	.0199	.0188	.0178	.0168	.0159	.0150	.0141	.0133
—0	0.0383	0.0263	0.0244	0.0225	0.0307	0.0291	0.0275	0.0260	0.0247	0.0234
+0	.0383	.0403	.0423	.0444	.0467	.0491	.0515	.0542	.0570	.0600
10	.0531	.0665	.0699	.0735	.0772	.0810	.0850	.0891	.0933	.0979
20	.1026	.1077	.1130	.1185	.1242	.1302	.1365	.1430	.1497	.1568
30	.1641	.1718	.1798							

(b) Pressures in millimetres of mercury; temperatures in degrees Fahrenheit.

Temp. F.	0°.0	1°.0	2°.0	3°.0	4°.0	5°.0	6°.0	7°.0	8°.0	9°.0
—50°	0.053	0.049	0.046	0.043	0.040	0.037	0.034	0.032	0.030	0.028
—40	.100	.094	.089	.084	.079	.074	.069	.065	.061	.057
—30	.176	.165	.155	.146	.138	.130	.123	.117	.111	.105
—20	.319	.301	.284	.268	.253	.239	.225	.212	.199	.187
—10	.564	.534	.505	.478	.452	.427	.403	.384	.358	.338
—0°	0.972	0.922	0.873	0.826	0.781	0.738	0.698	0.661	0.627	0.595
+0	.972	1.023	1.075	1.129	1.186	1.246	1.309	1.376	1.447	1.523
10	1.603	1.688	1.776	1.867	1.961	2.058	2.158	2.262	2.371	2.486
20	2.607	2.735	2.869	3.009	3.155	3.307	3.466	3.631	3.803	3.982
30	4.169	4.364	4.568							

(c) Pressures in inches of mercury; temperatures in degrees Centigrade.

Temp. C.	0°.0	1°.0	2°.0	3°.0	4°.0	5°.0	6°.0	7°.0	8°.0	9°.0
—0°	0.1798	0.1655	0.1524	0.1395	0.1290	0.1185	0.1091	0.0998	0.0916	0.0842
—10	.0772	.0706	.0645	.0588	.0537	.0491	.0449	.0411	.0375	.0341
—20	.0307	.0278	.0252	.0229	.0208	.0188	.0171	.0153	.0138	.0124
—30	.0112	.0101	.0091	.0082	.0073	.0065	.0059	.0053	.0048	.0044
—40	.0040	.0036	.0032	.0029	.0025	.0022	.0020	.0017	.0015	.0013

(d) Pressures in millimetres of mercury; temperatures in degrees Centigrade.

Temp. C.	0°.0	1°.0	2°.0	3°.0	4°.0	5°.0	6°.0	7°.0	8°.0	9°.0
—0°	4.568	4.208	3.875	3.565	3.277	3.009	2.767	2.534	2.327	2.138
—10	1.961	1.794	1.637	1.493	1.363	1.246	1.140	1.044	0.952	0.864
—20	0.781	0.706	0.641	0.583	0.528	0.478	0.432	0.389	0.350	0.315
—30	0.284	0.256	0.231	0.207	0.185	0.165	0.148	0.133	0.121	0.110
—40	0.100	0.090	0.081	0.072	0.064	0.057	0.050	0.044	0.039	0.034

* Marvin's results (Ann. Rept. U. S. Chief Signal Officer, 1891, App. 10).

PRESSURE OF AQUEOUS VAPOR IN THE ATMOSPHERE.

This table gives the vapor pressure corresponding to various values of the difference $t-t_1$ between the readings of dry and wet bulb thermometers and the temperature t_1 of the wet bulb thermometer. The differences $t-t_1$ are given by two-degree steps in the top line, and t_1 by degrees in the first column. Temperatures in Centigrade degrees and Regnault's vapor pressures in millimetres of mercury are used throughout the table. The table was calculated for barometric pressure B equal to 76 centimetres, and a correction is given for each centimetre at the top of the columns.*

t_1	$t-t_1=0$	2	4	6	6	10	12	14	16	18	20	Difference per 1° of $t-t_1$
Corrections for B per centimetre.†		.013	.026	.040	.053	.066	.079	.092	.106	.119	.132	
−10	1.96	0.96										0.100
−9	2.14	1.14	0.14									0.100
−8	2.33	1.33	0.33									0.100
−7	2.53	1.53	0.53									0.100
−6	2.76	1.76	0.76									0.100
−5	3.01	2.01	1.00									0.100
−4	3.28	2.28	1.27	0.27								0.100
−3	3.57	2.57	1.56	0.56								0.100
−2	3.88	2.88	1.87	0.87								0.100
−1	4.22	3.22	2.21	1.21	0.21							0.100
0	4.60	3.60	2.59	1.59	0.59							0.100
1	4.94	3.93	2.92	1.92	0.92							0.100
2	5.30	4.29	3.29	2.28	1.28	0.27						0.100
3	5.69	4.68	3.68	2.67	1.66	0.66						0.101
4	6.10	5.09	4.09	3.08	2.07	1.06	0.05					0.101
5	6.53	5.52	4.51	3.50	2.49	1.48	0.48					0.101
6	7.00	5.99	4.98	3.97	2.96	1.95	0.94					0.101
7	7.49	6.48	5.47	4.45	3.44	2.43	1.42	0.41				0.101
8	8.02	7.01	5.99	4.98	3.97	2.96	1.94	0.93				0.101
9	8.57	7.56	6.54	5.53	4.51	3.50	2.49	1.48	0.46			0.101
10	9.17	8.16	7.14	6.12	5.11	4.09	3.08	2.07	1.06	0.05		0.101
11	9.79	8.77	7.76	6.74	5.73	4.71	3.69	2.68	1.66	0.64		0.102
12	10.46	9.44	8.43	7.41	6.39	5.37	4.36	3.34	2.32	1.30	0.28	0.102
13	11.16	10.14	9.12	8.10	7.09	6.07	5.05	4.03	3.01	1.99	0.97	0.102
14	11.91	10.89	9.87	8.85	7.83	6.81	5.79	4.77	3.71	2.69	1.67	0.102
15	12.70	11.68	10.66	9.64	8.62	7.60	6.58	5.56	4.54	3.52	2.50	0.102
16	13.54	12.52	11.50	10.47	9.45	8.43	7.41	6.39	5.37	4.35	3.33	0.102
17	14.42	13.40	12.37	11.35	10.33	9.31	8.28	7.26	6.24	5.22	4.20	0.102
18	15.36	14.34	13.31	12.29	11.26	10.24	9.21	8.19	7.17	6.15	5.13	0.102
19	16.35	15.33	14.30	13.27	12.25	11.22	10.20	9.17	8.15	7.13	6.11	0.102
20	17.39	16.37	15.34	14.31	13.28	12.26	11.23	10.21	9.18	8.15	7.12	0.103
21	18.50	17.47	16.45	15.42	14 39	13.36	12.33	11.31	10.28	9.25	8.22	0.103
22	19.66	18.63	17.60	16.57	15.54	14.51	13.48	12.46	11.43	10.40	9.37	0.103
23	20.89	19.86	18.83	17.80	16.77	15.74	14.71	13.68	12.66	11.63	10.60	0.103
24	22.18	21.15	20.12	19.09	18.05	17.02	15.99	14.96	13.94	12.91	11.88	0.103
25	23.55	22.52	21.49	20.45	19.43	18.39	17.36	16.33	15.30	14.27	13.24	0.103
26	24.99	23.96	22.92	21.89	20.86	19.82	18.79	17.76	16.73	15.70	14.67	0.103
27	26.51	25.48	24.44	23.40	22.37	21.34	20.30	19.27	18.24	17.21	16.18	0.103
28	28.10	27.07	26.03	24.99	23.96	22.92	21.89	20.85	19.82	18.79	17.76	0.103
29	29.78	28.75	27.71	26.67	25.63	24.59	23.56	22.52	21.49	20.46	19.43	0.103
30	31.55	30.51	29.47	28.43	27.40	26.36	25.32	24.29	23.25	22.22	21.18	0 104
31	33.41	32.37	31.33	30 29	29.25	28.22	27.18	26.14	25.10	24.07	23.03	0.104
32	35.36	34.32	33.28	32.24	31.21	30.17	29.13	28.09	27.05	26.01	24 97	0.104
33	37.41	36.37	35.33	34.29	33.25	32.22	31.18	30.14	29.10	28.06	27.02	0.104
34	39.57	38.53	37.48	36.44	35.40	34.36	33.32	32.28	31.24	30.20	29.16	0.104
35	41.83	40.79	39.74	38.70	37.66	36.62	35.68	34.64	33.60	32.56	31.52	0.104
36	44.20	43.16	42.11	41.07	40.03	38.99	37.95	36.90	35.86	34.82	33.78	c.104
37	46.69	45.65	44.60	43.56	42.52	41.48	40.44	39.39	38.35	37.31	36.27	0.104
38	49.30	48.26	47.21	46.17	45.13	44.08	43.04	41.99	40.95	39.91	38.87	0.104
39	52.04	51.00	49.95	48.91	47.86	46.82	45.77	44.73	43.78	42.74	41.69	0.105

Example.

$t-t_1=7.2$

$t_1=10.0$

$B=74.5$

Tabular number $=6.12-6\times.101=5.51$

Correction for $B=1.5\times.048\ldots=.07$

Hence we get $p\ldots=5.58$

* The table was calculated from the formula $p=p_1-0.00066\,B(t-t_1)(1+0.00115\,t_1)$ (Ferrel, Annual Report U. S. Chief Signal Officer, 1886, App. 24).

† When B is less than 76 the correction is to be added, and when B is greater than 76 it is to be subtracted.

The first column of this table gives the temperatures of the wet-bulb thermometer, and the top line the difference the table. The dew-points were computed for a barometric pressure of 76 centimetres. When the barometer differs and the resulting number added to or subtracted from the tabular number according as the barometer is below or

t_1	$t-t_1=1$	2	3	4	5	6	7	8
	Dew-points corresponding to the difference of temperature given in the above line and the wet-bulb thermometer reading given in first column.							
$\delta T/\delta B=$	.04	.11	.22	.49				
−10	−13.2	−17.9						
−9	12.0	16.0	−22.0					
−8	10.7	14.3	19.4					
−7	9.5	12.7	17.1	−24.0				
−6	8.3	11.2	14.9	20.3				
$\delta T/\delta B=$	.03	.06	.11	.18	.31	.43		
−5	−7.1	−9.7	−12.9	−17.5	−24.5			
−4	6.0	8.3	11.1	14.8	20.1			
−3	4.8	6.9	9.4	12.6	16.8	−23.4		
−2	3.6	5.5	7.8	10.5	13.9	18.9		
−1	2.5	4.2	6.2	8.5	11.5	15.4	−21.0	
$\delta T/\delta B=$	.02	.04	.07	.10	.14	.19	.26	.38
0	−1.3	−2.9	−4.8	−6.8	−9.3	−12.3	−16.5	−22.9
1	0.3	1.7	3.5	5.3	7.6	10.2	13.5	18.3
2	+0.6	0.7	2.2	3.9	6.1	8.3	11.1	14.7
3	1.7	+0.2	1.0	2.6	4.6	6.4	8.9	11.9
4	2.8	1.4	0.0	1.3	3.1	4.7	6.9	9.4
$\delta T/\delta B=$	.02	.03	.05	.07	.09	.11	.14	.18
5	3.8	2.6	+1.2	−0.1	−1.6	−3.2	−5.0	−7.1
6	4.9	3.7	2.5	+1.1	0.2	1.7	3.3	5.2
7	6.0	4.9	3.7	2.4	+1.1	0.3	1.8	3.4
8	7.0	6.0	4.9	3.7	2.5	+1.1	0.3	1.8
9	8.1	7.1	6.1	5.0	3.9	2.6	+1.2	0.1
$\delta T/\delta B=$	.01	.02	.03	.05	.06	.08	.10	.12
10	9.1	8.3	7.3	6.3	5.2	4.1	2.8	+1.5
11	10.2	9.3	8.4	7.5	6.5	5.5	4.3	3.1
12	11.2	10.4	9.6	8.7	7.8	6.8	5.8	4.7
13	12.3	11.5	10.7	9.9	9.1	8.2	7.2	6.2
14	13.3	12.6	11.9	11.1	10.3	9.05	8.6	7.6
$\delta T/\delta B=$	.01	.02	.03	.04	.05	.06	.07	.08
15	14.4	13.7	13.0	12.3	11.5	10.8	9.9	9.1
16	15.4	14.8	14.1	13.5	12.7	12.0	11.3	10.5
17	16.4	15.8	15.2	14.6	13.9	13.3	12.6	11.8
18	17.5	16.9	16.3	15.7	15.1	14.5	13.8	13.1
19	18.5	18.0	17.4	16.9	16.3	15.7	15.1	14.4
$\delta T/\delta B=$	.005	.01	.015	.02	.027	.033	.04	.05
20	19.5	19.0	18.5	18.0	17.4	16.9	16.3	15.7
21	20.5	20.1	19.6	19.1	18.6	18.1	17.5	17.0
22	21.6	21.1	20.7	20.2	19.7	19.2	18.7	18.2
23	22.6	22.2	21.7	21.3	20.8	20.4	19.9	19.4
24	23.6	23.2	22.8	22.4	22.0	21.5	21.1	20.6
$\delta T/\delta B=$	.005	.01	.015	.02	.025	.03	.035	.04
25	24.6	24.2	23.9	23.5	23.1	22.7	22.2	21.8
26	25.6	25.3	24.9	24.5	24.2	23.8	23.4	23.0
27	26.7	26.3	26.0	25.6	25.3	24.9	24.5	24.1
28	27.7	27.3	27.0	26.7	26.4	26.0	25.7	25.3
29	28.7	28.4	28.1	27.8	27.4	27.1	26.8	26.4
$\delta T/\delta B=$	.003	.006	.01	.013	.017	.019	.022	.026
30	29.7	29.4	29.1	28.8	28.5	28.2	27.9	27.6
31	30.7	30.5	30.2	29.9	29.6	29.3	29.0	28.7
32	31.7	31.5	31.2	30.9	30.7	30.4	30.1	29.8
33	32.8	32.5	32.2	32.0	31.7	31.5	31.2	30.9
34	33.8	33.5	33.3	33.0	32.8	32.5	32.3	32.0
$\delta T/\delta B=$	.003	.005	.008	.010	.013	.016	.019	.021
35	34.8	34.5	34.3	34.1	33.8	33.6	33.4	33.1
36	35.8	35.5	35.3	35.1	34.9	34.6	34.4	34.2
37	36.8	36.6	36.4	36.2	36.0	35.7	35.5	35.3
38	37.8	37.6	37.4	37.2	37.0	36.8	36.6	36.4
39	38.8	38.6	38.4	38.2	38.0	37.9	37.6	37.5

between the dry and the wet bulb, when the dew-point has the values given at corresponding points in the body of from 76 centimetres the corresponding numbers in the lines marked $\delta T/\delta B$ are to be multiplied by the difference, or above 76. See examples.

t_1	$t-t_1=9$	10	11	12	13	14	15
	Dew-points corresponding to the difference of temperature given in the above line and the wet-bulb thermometer reading given in first column.						
$\delta T/\delta B=$	.45	.67					
0							
1							
2	−20.0						
3	15.8	−22.2					
4	12.4	16.8					
$\delta T/\delta B=$	.23	.29	.37	.44	.54	.66	.72
5	−19.8	−13.1	−17.7				
6	7.4	10.1	13.4	−18.1			
7	5.3	7.6	10.1	13.5	−18.3		
8	3.3	5.2	7.4	10.1	13.5	−18.3	
9	1.6	3.2	5.1	7.2	9.9	13.1	−17.2
$\delta T/\delta B=$	.14	.17	.20	.22	.25	.29	.36
10	0.0	−1.3	−3.0	−4.7	−6.8	−9.4	−12.5
11	+1.8	+0.3	1.0	2.6	4.3	6.3	8.8
12	3.5	2.2	+0.8	0.6	2.1	3.7	5.7
13	5.1	3.9	2.7	+1.3	0.1	1.6	3.1
14	6.7	5.6	4.5	3.3	+1.9	+0.5	0.9
$\delta T/\delta B=$	.09	.11	.12	.14	.16	.18	.20
15	8.2	7.2	6.2	5.1	3.9	2.7	+1.3
16	9.6	8.7	7.8	6.8	5.8	4.7	3.5
17	11.0	10.2	9.4	8.5	7.5	6.5	5.5
18	12.4	11.7	10.9	10.1	9.2	8.3	7.4
19	13.8	13.1	12.4	11.6	10.8	10.0	9.1
$\delta T/\delta B=$	.06	.07	.08	.09	.10	.11	.13
20	15.1	14.5	13.8	13.1	12.4	11.6	10.8
21	16.4	15.8	15.2	14.5	13.9	13.2	12.5
22	17.6	17.1	16.5	15.9	15.3	14.7	14.0
23	18.9	18.4	17.9	17.3	16.8	16.2	15.7
24	20.1	19.6	19.2	18.7	18.1	17.6	17.0
$\delta T/\delta B=$	.045	.05	.06	.06	.07	.08	.09
25	21.4	20.9	20.4	20.0	19.5	19.0	18.5
26	22.6	22.1	21.7	21.3	20.8	20.3	19.9
27	23.7	23.4	22.9	22.5	22.1	21.7	21.2
28	24.9	24.5	24.2	23.8	23.4	23.0	22.6
29	26.1	25.7	25.4	25.0	24.6	24.2	23.9
$\delta T/\delta B=$	.031	.035	.041	.047	.053	.06	.07
30	27.2	26.9	26.6	26.2	25.9	25.5	25.2
31	28.4	28.1	27.8	27.4	27.1	26.8	26.4
32	29.5	29.2	28.9	28.6	28.3	28.0	27.7
33	30.7	30.4	30.1	29.8	29.5	29.2	28.9
34	31.8	31.5	31.2	30.9	30.7	30.4	30.1
$\delta T/\delta B=$	.024	.027	.029	.032	.037	.037	.04
35	32.9	32.6	32.4	32.1	31.8	31.6	31.4
36	34.0	33.7	33.5	33.3	33.0	32.8	32.5
37	35.1	34.9	34.6	34.4	34.2	33.9	33.7
38	36.2	35.9	35.7	35.5	35.3	35.1	34.8
39	37.3	37.1	36.8	36.6	36.4	36.2	36.0

EXAMPLES.

(1) Given $B=72$, $t_1=10$, $t-t_1=5$.
Then tabular number for $t_1=10$ and $t-t_1=5$ is 5.2
Also $76-72=4$ and $\delta T/\delta B=.06$.
$\therefore$ Correction $=0.06\times 4=$ 24
Hence the dew-point is 5.44

(2) Given $B=71.5$, $t_1=7$, $t-t_1=8$.
Then, as above, tabulated number $=$ . . . 3.4
$\delta T/\delta B=\frac{.18+.12}{2}=.15$
Correction $=0.15\times 4.5=$ 67
Dew-point $=$ 4.07

VALUES OF 0.378 *e*.*

This table gives the humidity term $0.378e$, which occurs in the equation $\delta = \delta_0 \frac{h}{760} = \delta_0 \frac{B - 0.378e}{760}$ for the calculation of the density of the dry air in a sample containing aqueous vapor at pressure e; δ_0 is the density at normal barometric pressure, B the observed barometric pressure, and h the pressure corrected for humidity. For values of $\frac{h}{760}$ see Table 174. Temperatures are in degrees Centigrade, and pressures in millimetres of mercury.

Dew-point.	Vapor pressure. e	$0.378e$.	Dew-point.	Vapor pressure. e	$0.378e$.	Dew-point.	Vapor pressure. e	$0.378e$.
−30°	0.38	0.14	**0**	4.57	1.73	**30°**	31.51	11.91
−29	.42	.16	1	4.91	1.86	31	33.37	12.61
−28	.46	.17	2	5.27	1.99	32	35.32	13.35
−27	.50	.19	3	5.66	2.14	33	37.37	14.13
−26	.55	.21	4	6.07	2.29	34	39.52	14.94
−25	0.61	0.23	**5**	6.51	2.46	**35**	41.78	15.79
−24	.66	.25	6	6.97	2.63	36	44.16	16.69
−23	.73	.28	7	7.47	2.82	37	46.65	17.63
−22	.79	.30	8	7.99	3.02	38	49.26	18.62
−21	.87	.33	9	8.55	3.23	39	52.00	19.66
−20	0.94	0.36	**10**	9.14	3.45	**40**	54.87	20.74
−19	1.03	.39	11	9.77	3.69	41	57.87	21.86
−18	.12	.42	12	10.43	3.94	42	61.02	23.06
−17	.22	.46	13	11.14	4.21	43	64.31	24.31
−16	.32	.50	14	11.88	4.49	44	67.76	25.61
−15	1.44	0.54	**15**	12.67	4.79	**45**	71.36	26.97
−14	.56	.59	16	13.51	5.11	46	75.13	28.40
−13	.69	.64	17	14.40	5.44	47	79.07	29.89
−12	.84	.70	18	15.33	5.79	48	83.19	31.45
−11	.99	.75	19	16.32	6.17	49	87.49	33.07
−10	2.15	0.81	**20**	17.36	6.56	**50**	91.98	34.77
−9	.33	.88	21	18.47	6.98	51	96.66	36.54
−8	.51	.95	22	19.63	7.42	52	101.55	38.39
−7	.72	1.03	23	20.86	7.89	53	106.65	40.31
−6	.93	.11	24	22.15	8.37	54	111.97	42.32
−5	3.16	1.19	**25**	23.52	8.89	**55**	117.52	44.42
−4	.41	.29	26	24.96	9.43	56	123.29	46.60
−3	.67	.39	27	26.47	10.01	57	129.31	48.88
−2	.95	.49	28	28.07	10.61	58	135.58	51.25
−1	4.25	.61	29	29.74	11.24	59	142.10	53.71

* This table is quoted from "Smithsonian Meteorological Tables," p. 225.

RELATIVE HUMIDITY.*

This table gives the humidity of the air, for temperature *t* and dew-point *d* in Centigrade degrees, expressed in percentages of the saturation value for the temperature *t*.

Depression of the dew-point. $t-d$	Dew-point (d).					Depression of the dew-point. $t-d$	Dew-point (d).				
	−10	0	+10	+20	+30		−10	0	+10	+20	+30
C.						C.					
0°.0	100	100	100	100	100	**8°.0**	54	57	60	62	64
0.2	98	99	99	99	99	8.2	54	56	59	61	63
0.4	97	97	97	98	98	8.4	53	56	58	60	63
0.6	95	96	96	96	97	8.6	52	55	57	60	62
0.8	94	94	95	95	96	8.8	51	54	57	59	61
1.0	92	93	94	94	94	**9.0**	51	53	56	58	61
1.2	91	92	92	93	93	9.2	50	53	55	58	60
1.4	90	90	91	92	92	9.4	49	52	55	57	59
1.6	88	89	90	91	91	9.6	48	51	54	56	59
1.8	87	88	89	90	90	9.8	48	51	53	56	58
2.0	86	87	88	88	89	**10.0**	47	50	53	55	57
2.2	84	85	86	87	88	10.5	45	48	51	54	
2.4	83	84	85	86	87	11.0	44	47	49	52	
2.6	82	83	84	85	86	11.5	42	45	48	51	
2.8	80	82	83	84	85	12.0	41	44	47	49	
3.0	79	81	82	83	84	**12.0**	39	42	45	48	
3.2	78	80	81	82	83	13.0	38	41	44	46	
3.4	77	79	80	81	82	13.5	37	40	43	45	
3.6	76	77	79	80	82	14.0	35	38	41	44	
3.8	75	76	78	79	81	14.5	34	37	40	43	
4.0	73	75	77	78	80	**15.0**	33	36	39	42	
4.2	72	74	76	77	79	15.5	32	35	38	40	
4.4	71	73	75	77	78	16.0	31	34	37	39	
4.6	70	72	74	76	77	16.5	30	33	36	38	
4.8	69	71	73	75	76	17.0	29	32	35	37	
5.0	68	70	72	74	75	**17.5**	28	31	34	36	
5.2	67	69	71	73	75	18.0	27	30	33	35	
5.4	66	68	70	72	74	18.5	26	29	32	34	
5.6	65	67	69	71	73	19.0	25	28	31	33	
5.8	64	66	69	70	72	19.5	24	27	30	33	
6.0	63	66	68	70	71	**20.0**	24	26	29	32	
6.2	62	65	67	69	71	21.0	22	25	27		
6.4	61	64	66	68	70	22.0	21	23	26		
6.6	60	63	65	67	69	23.0	19	22	24		
6.8	60	62	64	66	68	24.0	18	21	23		
7.0	59	61	63	66	68	**25.0**	17	19	22		
7.2	58	60	63	65	67	26.0	16	18	21		
7.4	57	60	62	64	66	27.0	15	17	20		
7.6	56	59	61	63	65	28.0	14	16	19		
7.8	55	58	60	63	65	29.0	13	15	18		
8.0	54	57	60	62	64	**30.0**	12	14	17		

* Abridged from Table 45 of "Smithsonian Meteorological Tables."

DENSITY OF AIR FOR DIFFERENT PRESSURES AND HUMIDITIES.

TABLE 174.—Values of $\frac{h}{760}$, from $h = 1$ to $h = 9$, for the Computation of Different Values of the Ratio of Actual to Normal Barometric Pressure.

This gives the density of air at pressure h in terms of the density at normal atmosphere pressure. When the air contains moisture, as is usually the case with the atmosphere, we have the following equation for the dry air pressure: $h = B - 0.378e$, where e is the vapor pressure, and B the observed barometric pressure corrected for temperature. When the necessary observations are made the value of e may be taken from Table 170, and then $0.378e$ from Table 172, or the dew-point may be found and the value of $0.378e$ taken from Table 172.

h	$\frac{h}{760}$
1	0.0013158
2	.0026316
3	.0039474
4	0.0052632
5	.0065789
6	.0078947
7	0.0092105
8	.0105263
9	.0118421

EXAMPLES OF USE OF THE TABLE.

To find the value of $\frac{h}{760}$ when $h = 754.3$

$h =$ 700	gives	.92105
50	"	.065789
4	"	.005263
.3	"	.000395
754.3		.992497

To find the value of $\frac{h}{760}$ when $h = 5.73$

$h =$ 5	gives	.0065789
.7	"	.0007895
.03	"	.0000395
5.73		.0074079

TABLE 175.—Values of the logarithms of $\frac{h}{760}$ for values of h between 80 and 340.

Values from 8 to 80 may be got by subtracting 1 from the characteristic, and from 0.8 to 8 by subtracting 2 from the characteristic, and so on.

h	Values of $\log \frac{h}{760}$.									
	0	1	2	3	4	5	6	7	8	9
80	$\bar{1}.02228$	$\bar{1}.02767$	$\bar{1}.03300$	$\bar{1}.03826$	$\bar{1}.04347$	$\bar{1}.04861$	$\bar{1}.05368$	$\bar{1}.05871$	$\bar{1}.06367$	$\bar{1}.06858$
90	.07343	.07823	.08297	.08767	.09231	.09691	.10146	.10596	.11041	.11482
100	$\bar{1}.11919$	$\bar{1}.12351$	$\bar{1}.12779$	$\bar{1}.13202$	$\bar{1}.13622$	$\bar{1}.14038$	$\bar{1}.14449$	$\bar{1}.14857$	$\bar{1}.15261$	$\bar{1}.15661$
110	.16058	.16451	.16840	.17226	.17609	.17988	.18364	.18737	.19107	.19473
120	.19837	.20197	.20555	.20909	.21261	.21611	.21956	.22299	.22640	.22978
130	.23313	.23646	.23976	.24304	.24629	.24952	.25273	.25591	.25907	.26220
140	.26531	.26841	.27147	.27452	.27755	.28055	.28354	.28650	.28945	.29237
150	$\bar{1}.29528$	$\bar{1}.29816$	$\bar{1}.30103$	$\bar{1}.30388$	$\bar{1}.30671$	$\bar{1}.30952$	$\bar{1}.31231$	$\bar{1}.31509$	$\bar{1}.31784$	$\bar{1}.32058$
160	.32331	.32616	.32870	.33137	.33403	.33667	.33929	.34190	.34450	.34707
170	.34964	.35218	.35471	.35723	.35974	.36222	.36470	.36716	.36961	.37204
180	.37446	.37686	.37926	.38164	.38400	.38636	.38870	.39128	.39334	.39565
190	.39794	.40022	.40249	.40474	.40699	.40922	.41144	.41365	.41585	.41804
200	$\bar{1}.42022$	$\bar{1}.42238$	$\bar{1}.42454$	$\bar{1}.42668$	$\bar{1}.42882$	$\bar{1}.43094$	$\bar{1}.43305$	$\bar{1}.43516$	$\bar{1}.43725$	$\bar{1}.43933$
210	.44141	.44347	.44552	.44757	.44960	.45162	.45364	.45565	.45764	.45963
220	.46161	.46358	.46554	.46749	.46943	.47137	.47329	.47521	.47712	.47902
230	.48091	.48280	.48467	.48654	.48840	.49025	.49210	.49393	.49576	.49758
240	.49940	.50120	.50300	.50479	.50658	.50835	.51012	.51188	.51364	.51539
250	$\bar{1}.51713$	$\bar{1}.51886$	$\bar{1}.52059$	$\bar{1}.52231$	$\bar{1}.52402$	$\bar{1}.52573$	$\bar{1}.52743$	$\bar{1}.52912$	$\bar{1}.53081$	$\bar{1}.53249$
260	.53416	.53583	.53749	.53914	.54079	.54243	.54407	.54570	.54732	.54894
270	.55055	.55216	.55376	.55535	.55694	.55852	.56010	.56167	.56323	.56479
280	.56634	.56789	.56944	.57097	.57250	.57403	.57555	.57707	.57858	.58008
290	.58158	.58308	.58457	.58605	.58753	.58901	.59048	.59194	.59340	.59486
300	$\bar{1}.59631$	$\bar{1}.59775$	$\bar{1}.59919$	$\bar{1}.60063$	$\bar{1}.60206$	$\bar{1}.60349$	$\bar{1}.60491$	$\bar{1}.60632$	$\bar{1}.60774$	$\bar{1}.60914$
310	.61055	.61195	.61334	.61473	.61611	.61750	.61887	.62025	.62161	.62298
320	.62434	.62569	.62704	.62839	.62973	.63107	.63240	.63373	.63506	.63638
330	.63770	.63901	.64032	.64163	.64293	.64423	.64553	.64682	.64810	.64939
340	.65067	.65194	.65321	.65448	.65574	.65701	.65826	.65952	.66077	.66201

DENSITY OF AIR.

Values of logarithms of $\frac{h}{760}$ for values of h between 350 and 800.

h	Values of log $\frac{h}{760}$.									
	0	1	2	3	4	5	6	7	8	9
350	$\bar{1}$.66325	$\bar{1}$.66449	$\bar{1}$.66573	$\bar{1}$.66696	$\bar{1}$.66819	$\bar{1}$.66941	$\bar{1}$.67064	$\bar{1}$.67185	$\bar{1}$.67307	$\bar{1}$.67428
360	.67549	.67669	.67790	.67909	.68029	.68148	.68267	.68385	.68503	.68621
370	.68739	.68856	.68973	.69090	.69206	.69322	.69437	.69553	.69668	.69783
380	.69897	.70011	.70125	.70239	.70352	.70465	.70577	.70690	.70802	.70914
390	.71025	.71136	.71247	.71358	.71468	.71578	.71688	.71798	.71907	.72016
400	$\bar{1}$.72125	$\bar{1}$.72233	$\bar{1}$.72341	$\bar{1}$.72449	$\bar{1}$.72557	$\bar{1}$.72664	$\bar{1}$.72771	$\bar{1}$.72878	$\bar{1}$.72985	$\bar{1}$.73091
410	.73197	.73303	.73408	.73514	.73619	.73723	.73828	.73932	.74036	.74140
420	.74244	.74347	.74450	.74553	.74655	.74758	.74860	.74961	.75063	.75164
430	.75265	.75366	.75467	.75567	.75668	.75768	.75867	.75967	.76066	.76165
440	.76264	.76362	.76461	.76559	.76657	.76755	.76852	.76949	.77046	.77143
450	$\bar{1}$.77240	$\bar{1}$.77336	$\bar{1}$.77432	$\bar{1}$.77528	$\bar{1}$.77624	$\bar{1}$.77720	$\bar{1}$.77815	$\bar{1}$.77910	$\bar{1}$.78005	$\bar{1}$.78100
460	.78194	.78289	.78383	.78477	.78570	.78664	.78757	.78850	.78943	.79036
470	.79128	.79221	.79313	.79405	.79496	.79588	.79679	.79770	.78961	.79952
480	.80043	.80133	.80223	.80313	.80403	.80493	.80582	.80672	.80761	.80850
490	.80938	.81027	.81115	.81203	.81291	.81379	.81467	.81554	.81642	.81729
500	$\bar{1}$.81816	$\bar{1}$.81902	$\bar{1}$.81989	$\bar{1}$.82075	$\bar{1}$.82162	$\bar{1}$.82248	$\bar{1}$.82334	$\bar{1}$.82419	$\bar{1}$.82505	$\bar{1}$.82590
510	.82676	.82761	.82846	.82930	.83015	.83099	.83184	.83268	.83352	.83435
520	.83519	.83602	.83686	.83769	.83852	.83935	.84017	.84100	.84182	.84264
530	.84346	.84428	.84510	.84591	.84673	.84754	.84835	.84916	.84997	.85076
540	.85158	.85238	.85319	.85399	.85479	.85558	.85638	.85717	.85797	.85876
550	$\bar{1}$.85955	$\bar{1}$.86034	$\bar{1}$.86113	$\bar{1}$.86191	$\bar{1}$.86270	$\bar{1}$.86348	$\bar{1}$.86426	$\bar{1}$.86504	$\bar{1}$.86582	$\bar{1}$.86660
560	.86737	.86815	.86892	.86969	.87047	.87123	.87200	.87277	.87353	.87430
570	.87506	.87282	.87658	.87734	.87810	.87885	.87961	.88036	.88111	.88186
580	.88261	.88336	.88411	.88486	.88560	.88634	.88708	.88782	.88856	.88930
590	.89004	.89077	.89151	.89224	.89297	.89370	.89443	.89516	.89589	.89661
600	$\bar{1}$.89734	$\bar{1}$.89806	$\bar{1}$.89878	$\bar{1}$.89950	$\bar{1}$.90022	$\bar{1}$.90094	$\bar{1}$.90166	$\bar{1}$.90238	$\bar{1}$.90309	$\bar{1}$.90380
610	.90452	.90523	.90594	.90665	.90735	.90806	.90877	.90947	.91017	.91088
620	.91158	.91228	.91298	.91367	.91437	.91507	.91576	.91645	.91715	.91784
630	.91853	.91922	.91990	.92059	.92128	.92196	.92264	.92333	.92401	.92469
640	.92537	.92604	.92672	.92740	.92807	.92875	.92942	.93009	.93076	.93143
650	$\bar{1}$.93210	$\bar{1}$.93277	$\bar{1}$.93343	$\bar{1}$.93410	$\bar{1}$.93476	$\bar{1}$.93543	$\bar{1}$.93601	$\bar{1}$.93675	$\bar{1}$.93741	$\bar{1}$.93807
660	.93873	.93930	.94004	.94070	.94135	.94201	.94266	.94331	.94396	.94461
670	.94526	.94591	.94656	.94720	.94785	.94849	.94913	.94978	.95042	.95106
680	.95170	.95233	.95297	.95361	.95424	.95488	.95551	.95614	.95677	.95741
690	.95804	.95866	.95929	.95992	.96055	.96117	.96180	.96242	.96304	.96366
700	$\bar{1}$.96428	$\bar{1}$.96490	$\bar{1}$.96552	$\bar{1}$.96614	$\bar{1}$.96676	$\bar{1}$.96738	$\bar{1}$.96799	$\bar{1}$.96861	$\bar{1}$.96922	$\bar{1}$.96983
710	.97044	.97106	.97167	.97228	.97288	.97349	.97410	.97471	.97531	.97592
720	.97652	.97712	.97772	.97832	.97892	.97951	.98012	.98072	.98132	.98191
730	.98251	.98310	.98370	.98429	.98488	.98547	.98606	.98665	.98724	.98783
740	.98842	.98900	.98959	.99018	.99076	.99134	.99193	.99251	.99309	.99367
750	$\bar{1}$.99425	$\bar{1}$.99483	$\bar{1}$.99540	$\bar{1}$.99598	$\bar{1}$.99656	$\bar{1}$.99713	$\bar{1}$.99771	$\bar{1}$.99828	$\bar{1}$.99886	$\bar{1}$.99942
760	0.00000	0.00057	0.00114	0.00171	0.00228	0.00285	0.00342	0.00398	0.00455	0.00511
770	.00568	.00624	.00680	.00737	.00793	.00849	.00905	.00961	.01017	.01072
780	.01128	.01184	.01239	.01295	.01350	.01406	.01461	.01516	.01571	.01626
790	.01681	.01736	.01791	.01846	.01901	.01955	.02010	.02064	.02119	.02173

VOLUME OF PERFECT GASES.

Values of $1+.00367\,t$.

The quantity $1+.00367\,t$ gives for a perfect gas the volume at t° when the pressure is kept constant, or the pressure at t° when the volume is kept constant, in terms of the volume or the pressure at 0°.

(a) This part of the table gives the values of $1+.00367\,t$ for values of t between 0° and 10° C. by tenths of a degree.

(b) This part gives the values of $1+.00367\,t$ for values of t between −90° and +1990° C. by 10° steps.

These two parts serve to give any intermediate value to one tenth of a degree by a simple computation as follows: — In the (*b*) table find the number corresponding to the nearest lower temperature, and to this number add the decimal part of the number in the (*a*) table which corresponds to the difference between the nearest temperature in the (*b*) table and the actual temperature. For example, let the temperature be 682°.2:

We have for 680 in table (*b*) the number	3.49560
And for 2.2 in table (*a*) the decimal	.00807
Hence the number for 682.2 is	3.50367

(c) This part gives the logarithms of $1+.00367\,t$ for values of t between −49° and +399° C. by degrees.

(d) This part gives the logarithms of $1+.00367\,t$ for values of t between 400° and 1990° C. by 10° steps.

(a) Values of $1+.00367\,t$ for Values of t between 0° and 10° C. by Tenths of a Degree.

t	0.0	0.1	0.2	0.3	0.4
0	1.00000	1.00037	1.00073	1.00110	1.00147
1	.00367	.00404	.00440	.00477	.00514
2	.00734	.00771	.00807	.00844	.00881
3	.01101	.01138	.01174	.01211	.01248
4	.01468	.01505	.01541	.01578	.01615
5	1.01835	1.01872	1.01908	1.01945	1.01982
6	.02202	.02239	.02275	.02312	.02349
7	.02569	.02606	.02642	.02679	.02716
8	.02936	.02973	.03009	.03046	.03083
9	.03303	.03340	.03376	.03413	.03450

t	0.5	0.6	0.7	0.8	0.9
0	1.00184	1.00220	1.00257	1.00294	1.00330
1	.00550	.00587	.00624	.00661	.00697
2	.00918	.00954	.00991	.01028	.01064
3	.01284	.01321	.01358	.01395	.01431
4	.01652	.01688	.01725	.01762	.01798
5	1.02018	1.02055	1.02092	1.02129	1.02165
6	.02386	.02422	.02459	.02496	.02532
7	.02752	.02789	.02826	.02863	.02899
8	.03120	.03156	.03193	.03290	.03266
9	.03486	.03523	.03560	.03597	.03633

VOLUME OF PERFECT GASES.

(b) Values of 1 + .00367 t for Values of t between −90° and +1900° C. by 10° Steps.

t	00	10	20	30	40
−000	1.00000	0.96330	0.92660	0.88990	0.85320
+000	1.00000	1.93670	1.07340	1.11010	1.14680
100	1.36700	1.40370	1.44040	1.44710	1.51380
200	1.73400	1.77070	1.80740	1.84410	1.88080
300	2.10100	2.13770	2.17440	2.21110	2.24780
400	2.46800	2.50470	2.54140	2.57810	2.61480
500	2.83500	2.87170	2.90840	2.94510	2.98180
600	3.20200	3.23870	3.27540	3.31210	3.34880
700	3.56900	3.60570	3.64240	3.67910	3.71580
800	3.93600	3.97270	4.00940	4.04610	4.08280
900	4.30300	4.33970	4.37640	4.41310	4.44980
1000	4.67000	4.70670	4.74340	4.78010	4.81680
1100	5.03700	5.07370	5.11040	5.14710	5.18380
1200	5.40400	5.44070	5.47740	5.51410	5.55080
1300	5.77100	5.80770	5.84440	5.88110	5.91780
1400	6.13800	6.17470	6.21140	6.24810	6.28480
1500	6.50500	6.54170	6.57840	6.61510	6.65180
1600	6.87200	6.90870	6.94540	6.98210	7.01880
1700	7.23900	7.27570	7.31240	7.34910	7.38580
1800	7.60600	7.64270	7.67940	7.71610	7.75280
1900	7.97300	8.00970	8.04640	8.08310	8.11980
2000	8.34000	8.37670	8.41340	8.45010	8.48680

t	50	60	70	80	90
−000	0.81650	0.77980	0.74310	0.70640	0.66970
+000	1.18350	1.22020	1.25690	1.29360	1.33030
100	1.55050	1.58720	1.62390	1.66060	1.69730
200	1.91750	1.95420	1.99090	2.02760	2.06430
300	2.28450	2.32120	2.55790	2.39460	2.43130
400	2.65150	2.68820	2.72490	2.76160	2.79830
500	3.01850	3.05520	3.09190	3.12860	3.16530
600	3.38550	3.42220	3.45890	3.49560	3.53230
700	3.75250	3.78920	3.82590	3.86260	3.89930
800	4.11950	4.15620	4.19290	4.22960	4.26630
900	4.48650	4.52320	4.55990	4.59660	4.63330
1000	4.85350	4.89020	4.92690	4.96360	5.00030
1100	5.22050	5.25720	5.29390	5.33060	5.36730
1200	5.58750	5.62420	5.66090	5.69760	5.73430
1300	5.95450	5.99120	6.02790	6.06460	6.10130
1400	6.32150	6.35820	6.39490	6.43160	6.46830
1500	6.68850	6.72520	6.76190	6.79860	6.83530
1600	7.05550	7.09220	7.12890	7.16560	7.20230
1700	7.42250	7.45920	7.49590	7.53260	7.56930
1800	7.78950	7.82620	7.86290	7.89960	7.93630
1900	8.15650	8.19320	8.22990	8.26660	8.30330
2000	8.52350	8.56020	8.59690	8.63360	8.67030

VOLUME OF

(e) Logarithms of 1 + .00367 t for Values

t	0	1	2	3	4	Mean diff. per degree.
—40	$\bar{1}$.931051	$\bar{1}$.929179	$\bar{1}$.927299	$\bar{1}$.925410	$\bar{1}$.923513	**1884**
—30	.949341	.947546	.945744	.943934	.942117	1805
—20	.966892	.965169	.963438	.961701	.959957	1733
—10	.983762	.982104	.980440	.978769	.977092	1667
—0	0.000000	.998403	.996801	.995192	.993577	1605
+0	0.000000	0.001591	0.003176	0.004755	0.006329	**1582**
10	.015653	.017188	.018717	.020241	.021760	1526
20	.030762	.032244	.033721	.035193	.036661	1474
30	.045362	.046796	.048224	.049648	.051068	1426
40	.059488	.060875	.062259	.063637	.065012	1381
50	0.073168	0.074513	0.075853	0.077190	0.078522	**1335**
60	.086431	.087735	.089036	.090332	.091624	1299
70	.099301	.100567	.101829	.103088	.104344	1259
80	.111800	.113030	.114257	.115481	.116701	1226
90	.123950	.125146	.126339	.127529	.128716	1191
100	0.135768	0.136933	0.138094	0.139252	0.140408	**1158**
110	.147274	.248408	.149539	.150667	.151793	1129
120	.158483	.159588	.160691	.161790	.162887	1101
130	.169410	.170488	.171563	.172635	.173705	1074
140	.180068	.181120	.182169	.183216	.184260	1048
150	0.190472	0.191498	0.192523	0.193545	0.194564	**1023**
160	.200632	.201635	.202635	.203634	.204630	1000
170	.210559	.211540	.212518	.213494	.214468	976
180	.220265	.221224	.222180	.223135	.224087	956
190	.229959	.230697	.231633	.232567	.233499	935
200	0.239049	0.239967	0.240884	0.241798	0.242710	**916**
210	.248145	.249044	.249942	.250837	.251731	897
220	.257054	.257935	.258814	.259692	.260567	878
230	.265784	.266648	.267510	.268370	.269228	861
240	.274343	.275189	.276034	.276877	.277719	844
250	0.282735	0.283566	0.284395	0.285222	0.286048	**828**
260	.290969	.291784	.292597	.293409	.294219	813
270	.299049	.299849	.300648	.301445	.302240	798
280	.306982	.307768	.308552	.309334	.310115	784
290	.314773	.315544	.316314	.317083	.317850	769
300	0.322426	0.323184	0.323941	0.324696	0.325450	**756**
310	.329947	.330692	.331435	.332178	.332919	743
320	.337339	.338072	.338803	.339533	.340262	730
330	.344608	.345329	.345048	.346766	.347482	719
340	.351758	.352466	.353174	.353880	.354585	707
350	0.358791	0.359488	0.360184	0.360879	0.361573	**696**
360	.365713	.366399	.367084	.367768	.368451	684
370	.372525	.373201	.373875	.374549	.375221	674
380	.379233	.379898	.380562	.381225	.381887	664
390	.385439	.386494	.387148	.387801	.388453	654

PERFECT GASES.

of *t* between —40° and +399° C. by Degrees.

t	5	6	7	8	9	Mean diff. per degree.
—40	$\bar{1}$.921608	$\bar{1}$.919695	$\bar{1}$.917773	$\bar{1}$.915843	$\bar{1}$.913904	**1926**
—30	.940292	.938460	.936619	.934771	.932915	1845
—20	.958205	.956447	.954681	.952909	.951129	1771
—10	.975409	.973719	.972022	.970319	.968609	1699
—0	.991957	.990330	.988697	.987058	.985413	1636
+0	0.007897	0.009459	0.011016	0.012567	0.014113	**1554**
10	.023273	.024781	.026284	.027782	.029274	1500
20	.038123	.039581	.041034	.042481	.043924	1450
30	.052482	.053893	.055298	.056699	.058096	1402
40	.066382	.067748	.069109	.070466	.071819	1359
50	0.079847	0.081174	0.082495	0.083811	0.085123	**1315**
60	.092914	.094198	.095516	.096715	.098031	1281
70	.105595	.106843	.108088	.109329	.110566	1243
80	.117917	.119130	.120340	.121547	.122750	1210
90	.129899	.131079	.132256	.133430	.134601	1175
100	0.141559	0.142708	0.143854	0.144997	0.146137	**1144**
110	.152915	.154034	.155151	.156264	.157375	1115
120	.163981	.164072	.166161	.167246	.168330	1087
130	.174772	.175836	.176898	.177958	.179014	1060
140	.185301	.186340	.187377	.188411	.189443	1035
150	0.195581	0.196596	0.197608	0.198619	0.199626	**1011**
160	.205624	.206615	.207605	.208592	.209577	988
170	.215439	.216409	.217376	.218341	.219904	966
180	.225038	.225986	.226932	.227876	.228819	946
190	.234429	.235357	.236283	.237207	.238129	925
200	0.243621	0.244529	0.245436	0.246341	0.247244	**906**
210	.252623	.253512	.254400	.255287	.256172	887
220	.261441	.262313	.263184	.264052	.264919	870
230	.270085	.270940	.271793	.272644	.273494	853
240	.278559	.279398	.280234	.281070	.281903	836
250	0.286872	0.287694	0.288515	0.289326	0.290153	**820**
260	.295028	.295835	.296860	.297445	.298248	805
270	.303034	.303827	.304618	.305407	.306196	790
280	.310895	.311673	.312450	.313226	.314000	776
290	.318616	.319381	.320144	.320906	.321667	763
300	0.326203	0.326954	0.327704	0.328453	0.329201	**750**
310	.333659	.334397	.335135	.335871	.336606	737
320	.340989	.341715	.342441	.343164	.343887	724
330	.348198	.348912	.349624	.350337	.351048	713
340	.355289	.355991	.356693	.357394	.358093	701
350	0.362266	0.362957	0.363648	0.364337	0.365025	**690**
360	.369132	.369813	.370493	.371171	.371849	678
370	.375892	.376562	.377232	.377900	.378567	668
380	.382548	.383208	.383868	.384525	.385183	658
390	.389104	.389754	.390403	.391052	.391699	648

VOLUME OF PERFECT GASES.

(d) Logarithms of 1 + .00367 t for Values of t between 400° and 1990° C. by 10° Steps.

t	00	10	20	30	40
400	0.392345	0.398756	0.405073	0.411300	0.417439
500	0.452553	0.458139	0.463654	0.469100	0.474479
600	.505421	.510371	.515264	.520103	.524889
700	.552547	.556990	.561388	.565742	.570052
800	.595055	.599086	.603079	.607037	.610958
900	.633771	.637460	.641117	.644744	.648341
1000	0.669317	0.672717	0.676090	0.679437	0.682759
1100	.702172	.705325	.708455	.711563	.714648
1200	.732715	.735655	.738575	.741745	.744356
1300	.761251	.764004	.766740	.769459	.772160
1400	.788027	.790616	.793190	.795748	.798292
1500	0.813247	0.815691	0.818120	0.820536	0.822939
1600	.837083	.839396	.841697	.843986	.846263
1700	.859679	.861875	.864060	.866234	.868398
1800	.881156	.883247	.885327	.887398	.889459
1900	.901622	.903616	.905602	.907578	.909545

t	50	60	70	80	90
400	0.423492	0.429462	0.435351	0.441161	0.446894
500	0.479791	0.485040	0.490225	0.495350	0.500415
600	.529623	.534305	.538938	.543522	.548058
700	.574321	.578548	.582734	.586880	.590987
800	.614845	.618696	.622515	.626299	.630051
900	.651908	.655446	.658955	.662437	.665890
1000	0.686055	0.689327	0.692574	0.695797	0.698996
1100	.717712	.720755	.723776	.726776	.729756
1200	.747218	.750061	.752886	.755692	.758480
1300	.774845	.777514	.780166	.782802	.785422
1400	.800820	.803334	.805834	.808319	.810790
1500	0.825329	0.827705	0.830069	0.832420	0.834758
1600	.848828	.850781	.853023	.855253	.857471
1700	.870550	.872692	.874824	.876945	.879056
1800	.891510	.893551	.895583	.897605	.899618
1900	.911504	.913454	.915395	.917327	.919251

DETERMINATION OF HEIGHTS BY THE BAROMETER.

Formula of Babinet: $Z = C \frac{B_0 - B}{B_0 + B}$

C (in feet) $= 52494 \left[1 + \frac{t_0 + t - 64}{900}\right]$ English measures.

C (in metres) $= 16000 \left[1 + \frac{2(t_0 + t)}{1000}\right]$ metric measures.

In which Z = difference of height of two stations in feet or metres.

B_0, B = barometric readings at the lower and upper stations respectively, corrected for all sources of instrumental error.

t_0, t = air temperatures at the lower and upper stations respectively.

Values of C.

English Measures.			Metric Measures.		
$\frac{1}{2}(t_0+t)$.	C	Log C	$\frac{1}{2}(t_0+t)$.	C	Log C
Fahr.	Feet.		Cent.	Metres.	
10°	49928	4.69834	−10°	15360	4.18639
15	50511	.70339	−8	15488	.19000
			−6	15616	.19357
20	51094	4.70837	−4	15744	.19712
25	51677	.71330	−2	15872	.20063
30	52261	4.71818	0	16000	4.20412
35	52844	.72300	+2	16128	.20758
			4	16256	.21101
40	53428	4.72777	6	16384	.21442
45	54011	.73248	8	16512	.21780
50	54595	4.73715	10	16640	4.22115
55	55178	.74177	12	16768	.22448
			14	16896	.22778
60	55761	4.74633	16	17024	.23106
65	56344	.75085	18	17152	.23431
70	56927	4.75532	20	17280	4.23754
75	57511	.75975	22	17408	.24075
			24	17536	.24393
80	58094	4.76413	26	17664	.24709
85	58677	.76847	28	17792	.25022
90	59260	4.77276	30	17920	4.25334
95	59844	.77702	32	18048	.25643
			34	18176	.25950
100	60427	4.78123	36	18304	.26255

BAROMETRIC

Barometric pressures corresponding to different
This table is useful when a boiling-point apparatus is used

(a) British Measure.

Temp. F.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
185°	17.05	17.08	17.12	17.16	17.20	17.23	17.27	17.31	17.35	17.39
186	17.42	17.46	17.50	17.54	17.58	17.61	17.65	17.69	17.73	17.77
187	17.81	17.84	17.88	17.92	17.96	18.00	18.04	18.08	18.12	18.16
188	18.20	18.24	18.27	18.31	18.35	18.39	18.43	18.47	18.51	18.55
189	18.59	18.63	18.67	18.71	18.75	18.79	18.83	18.87	18.91	18.95
190	19.00	19.04	19.08	19.12	19.16	19.20	19.24	19.28	19.32	19.36
191	19.41	19.45	19.49	19.53	19.57	19.61	19.66	19.70	19.74	19.78
192	19.82	19.87	19.91	19.95	19.99	20.04	20.08	20.12	20.17	20.21
193	20.25	20.29	20.34	20.38	20.42	20.47	20.51	20.55	20.60	20.64
194	20.68	20.73	20.77	20.82	20.86	20.90	20.95	20.99	21.04	21.08
195	21.13	21.17	21.22	21.26	21.30	21.35	21.39	21.44	21.48	21.53
196	21.58	21.62	21.67	21.71	21.76	21.80	21.85	21.89	21.94	21.99
197	22.03	22.08	22.12	22.17	22.22	22.26	22.31	22.36	22.40	22.45
198	22.50	22.54	22.59	22.64	22.69	22.73	22.78	22.83	22.88	22.92
199	22.97	23.02	23.07	23.11	23.16	23.21	23.26	23.31	23.36	23.40
200	23.45	23.50	23.55	23.60	23.65	23.70	23.75	23.80	23.85	23.89
201	23.94	23.99	24.04	24.09	24.14	24.19	24.24	24.29	24.34	24.39
202	24.44	24.49	24.54	24.59	24.64	24.69	24.74	24.80	24.85	24.90
203	24.95	25.00	25.05	25.10	25.15	25.21	25.26	25.31	25.36	25.41
204	25.46	25.52	25.57	25.62	25.67	25.73	25.78	25.83	25.88	25.94
205	25.99	26.04	26.10	26.15	26.20	26.25	26.31	26.36	26.42	26.47
206	26.52	26.58	26.63	26.68	26.74	26.79	26.85	26.90	26.96	27.01
207	27.07	27.12	27.18	27.23	27.29	27.34	27.40	27.45	27.51	27.56
208	27.62	27.67	27.73	27.79	27.84	27.90	27.95	28.01	28.07	28.12
209	28.18	28.24	28.29	28.35	28.41	28.46	28.52	28.58	28.64	28.69
210	28.75	28.81	28.87	28.92	28.98	29.04	29.10	29.16	29.21	29.27
211	29.33	29.39	29.45	29.51	29.57	29.62	29.68	29.74	29.80	29.86
212	29.92	29.98	30.04	30.10	30.16	30.22	30.28	30.34	30.40	30.46

PRESSURES.

temperatures of the boiling-point of water.
in place of the barometer for the determination of heights.

(b) Metric Measure.*

Temp. C.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
80°	354.6	356.1	357.5	359.0	360.4	361.9	363.3	364.8	366.3	367.8
81	369.3	370.8	372.3	373.8	375.3	376.8	378.3	379.8	381.3	382.9
82	384.4	385.9	387.5	389.0	390.6	392.2	393.7	395.3	396.9	398.5
83	400.1	401.7	403.3	404.9	406.5	408.1	409.7	411.3	413.0	414.6
84	416.3	417.9	419.6	421.2	422.9	424.6	426.2	427.9	429.6	431.3
85	433.0	434.7	436.4	438.1	439.9	441.6	443.3	445.1	446.8	448.6
86	450.3	452.1	453.8	455.6	457.4	459.2	461.0	462.8	464.6	466.4
87	468.2	470.0	471.8	473.7	475.5	477.3	479.2	481.0	482.9	484.8
88	486.6	488.5	490.4	492.3	494.2	496.1	498.0	499.9	501.8	503.8
89	505.7	507.6	509.6	511.5	513.5	515.5	517.4	519.4	521.4	523.4
90	525.4	527.4	529.4	531.4	533.4	535.5	537.5	539.6	541.6	543.7
91	545.7	547.8	549.9	551.9	554.0	556.1	558.2	560.3	562.4	564.6
92	566.7	568.8	571.0	573.1	575.3	577.4	579.6	581.8	584.0	586.1
93	588.3	590.5	592.7	595.0	597.2	599.4	601.6	603.9	606.1	608.4
94	610.7	612.9	615.2	617.5	619.8	622.1	624.4	626.7	629.0	631.4
95	633.7	636.0	638.4	640.7	643.1	645.5	647.9	650.2	652.6	655.0
96	657.4	659.9	662.3	664.7	667.1	669.6	672.0	674.5	677.0	679.4
97	681.9	684.4	686.9	689.4	691.9	694.5	697.0	699.5	702.1	704.6
98	707.2	709.7	712.3	714.9	717.5	720.1	722.7	725.3	727.9	730.5
99	733.2	735.8	738.5	741.2	743.8	746.5	749.2	751.9	754.6	757.3
100	760.0	762.7	765.5	768.2	770.9	773.7	776.5	779.2	782.0	784.8

* Pressures in millimetres of mercury.

STANDARD WAVE-LENGTHS.

This table is an abridgment of the table published by Rowland (Phil. Mag. [5] vol. 36, pp. 49–75). The first column gives the number of the line reckoned from the beginning of Rowland's table, and thus indicates the number of lines of the table that have been omitted. The second column gives the chemical symbol of the element represented by the line of the spectrum. The third column indicates approximately the relative intensity of the lines recorded and also their appearance; *R* stands for reversed, *d* for double, ? for doubtful or difficult. The fourth column gives the relative "weights" to be attached to the values of the wave-lengths as standards. The last column gives the values of the wave-lengths in Ångström's units, *i. e.*, in ten millionths of a millimetre in ordinary air at about 20° C. and 760 millimetres pressure. When two or more elements are on the same line of the table it indicates that they have apparently coincident lines in the spectrum for that wave-length. When two or more lines are bracketed it means that the first one has a line coinciding with one side of the corresponding line in the solar spectrum and so on in order. Lines marked *A*(*o*) and *A*(*wv*) denote lines due to absorption by the oxygen or water vapor in the earth's atmosphere. The letters placed in front of some of the numbers in the first column are the symbols of well-known lines in the spectrum. The footnotes are from Rowland's paper.

No. of line.	Element.	Intensity and appearance.	Weight.	Wave-length (arc spectrum).
1	Sr	2	1	2152.912
4	Si	3	2	2210.939
7	Si	2	2	2218.146
9	Al	4	2	2269.161
11	Ca	20 *R*	3	2275.602
14	Ba	20 *R*	1	2335.267
16	Fe	–	2	2348.385
19	Al	7	3	2373.213
22	Fe	–	2	2388.710
24	Ca	25 *R*	5	2398.667
29	Si	8	15	2435.247
31	Si	3	10	2443.460
33	Si	3	10	2452.219
37*	C	10	15	2478.661
46	Bo	20	20	2497.821
51	Si	15	7	2516.210
55	Si	9	10	2524.206
59†	Hg	50 *R*	2	2536.648
63	Al	10	5	2568.085
68	Mn	–	2	2593.810
i 73	Si	5	7	2631.392
77	Fe	–	3	2720.989
78	Ca	5	1	2721.762
82	Fe	–	3	2742.485
85	Fe	–	3	2756.427
99	Mg	20 *R*	12	2795.632
102	Mg	20 *R*	10	2802.805
106	Fe	4	7	2832.545
111	Mg	100 *R*	15	2852.239
112	Si	15	12	2881.695
115	Fe	10 *R*	4	2937.020
117	Fe	7 *R*	4	2954.058
121	Fe	8 *R*	12	2967.016
124	Fe	12 *R*	15	2973.358
126	Fe	10 *R*	15	2983.689
129	Fe	8 *R*	18	2994.547
131	Ca	10 *R*	3	2997.430
135	Fe	8 *R*	15	3001.070
136	Ca	15 *R*	3	3006.978
141	Fe	6 *R*	15	3008.255
151	Fe	25 *R*	18	3020.759
163	Fe	20 *R*	13	3047.720
169	Fe	10 *R*	15	3059.200
				(Sun spectrum.)
136	?	3	–	3005.160
144	?	4	–	3012.557
154	?	5	7	3024.475
158	?	5	7	3035.850
164	?	3 *d*	5	3050.212
171	Co	3	5	3061.930
177	Fe?	4	6	3078.148
187	?	2	9	3094.739
197	Va‡	5	9	3121.275
201	–	3	5	3140.869
203	Mn	1	5	3167.290
207	Cr?	4	5	3188.164
209	Ti	4	5	3200.032
211	Ti	3	6	3218.390
215	Ti	4	3	3224.368
222	Cu	9	5	3247.680

* Seems to be the only single carbon line not belonging to a band in the arc spectrum. It was determined to belong to carbon by the spark spectrum.

† This line appears as a sharp reversal, with no shading, in the spectra of all substances tried that contained any trace of a continuous spectrum in the region.

‡ There is a faint line visible on the violet side.

STANDARD WAVE-LENGTHS.

No. of Line.	Element.	Intensity and appearance.	Weight.	Wave-length (sun spectrum).	No. of Line.	Element.	Intensity and appearance.	Weight.	Wave-length (sun spectrum).
224	Va	4	10	3267.839	409†	Fe?	10	3	4005.305
229	Na	6	6	3302.501	410	Fe	3	7	4016.578
235	Ti	5	10	3318.163	417	Fe	20	7	4045.975
239	Zr	1	8	3356.222	420	Mn	5	13	4055.701
241	Fe	2	12	3389.887	422	Fe	15	7	4063.756
244	Fe	4	18	3406.955	424	Fe	4	14	4073.920
250	Co	4	10	3455.384	428	Fe	2	8	4088.716
255	Co, Fe, Ni	4	10	3478.001	431	Fe	4	14	4114.600
261	Fe	3	4	3500.721	434	Fe	3	17	4157.948
265	Co	5	10	3518.487	436	Fe	3	20	4185.063
269	Fe	5	10	3540.266	439	Fe	5	4	4202.188
274	{ Ti, Fe }	4 *d*?	12	3564.680	*g* 445	Ca	10	10	4226.892
					448	Cr	7	15	4254.502
278	Fe	40	6	3581.344	451	Fe	8	9	4271.924
279	Fe?	4	12	3583.483	456	?	4	14	4293.249
284	Fe	4	12	3597.192		{ Ca	2 }	3	4307.904
290	Fe	15	10	3609.015	*G* 462	–	– } *d*	3	4308.034
292	Fe	4	15	3612.217		Fe }	5 }	10	4308.071
294	Fe	20	10	3618.924	*f* 465	Fe	8	15	4325.940
298	Fe	4	14	3623.332	467	Fe	3	17	4352.903
301	Fe	20	10	3631.619	*d* 471	Fe	10	11	4383.721
307	Fe	10	11	3647.995	473	Fe	8	11	4404.927
311	Fe	3	13	3667.397	477	Ca	4	7	4425.609
					480‡	Fe	5	18	4447.899
313	{ Co, Fe, Va }	6	13	3683.202	484	Fe	5	18	4494.735
320	Fe	5	11	3707.186	490	Ti	4	17	4508.456
324	Fe	50	10	3720.086	493	Ba	7	8	4554.213
327	Fe	5	15	3732.542	496	Ti	6	14	4572.157
338	Fe	20	8	3789.633	500	Fe	4	20	4602.183
341	Fe	15	7	3758.379	505	{ Ti, Co }	5	13	4629.515
348	Fe	3	15	3781.330	508	Fe	4	17	4643.645
355	Fe	3	15	3804.153	512	Fe	6	12	4679.028
358	Fe	30	4	3820.567	515	Ni	4	12	4686.395
361	Fe	20	4	3826.024	518§	Mg	9	11	4703.180
369	Fe	5	8	3843.406	524	Mn	6	1	4783.601
371	Fe	10	3	3860.048	528	Mn	6	12	4823.697
375	C	7	3	3883.472	*F* 531	H	15	5	4861.496
379	Fe	4	12	3897.599	537	Fe	7	4	4919.183
382	Ti	4	15	3924.669	545	{ Ti, Fe }	3	10	4973.274
K 387*	Ca	300	5	3933.809					
391	Al	10	7	3944.159	549	Fe	4	7	4994.316
393	Fe	4	15	3950.101	558	Ti	3	8	5020.210
397	Fe	3	11	3960.429	561	Fe	5	12	5050.008
H 399	Ca	200	5	3968.620	564	Fe	4	14	5068.946
404	Fe, Ti	4	14	3981.914	567	Fe	2	9	5090.959

* This line is doubly reversed and spread out in broad shading for 6.000 to 7.000 on either side. In each case the second reversal is slightly excentric with respect to the other, being displaced towards the red.

† Seven or eight lines, the brightest, and most of the others are due to iron.

‡ There is a faint side line towards the red.

§ This line is shaded towards the violet, probably due to a close side line.

TABLE 179.

STANDARD WAVE-LENGTHS.

No. of Line.	Element.	Intensity and appearance.	Weight.	Wave-length (sun spectrum).	No. of Line.	Element.	Intensity and appearance.	Weight.	Wave-length (sun spectrum).
570	Fe	2	11	5109.825	762	Fe	6	14	5930.410
575	Fe	4	9	5127.530	764	Si	6	14	5948.761
580	Fe	3	5	5141.916	770	Fe	6	7	5987.286
589	Fe	4	13	5162.448	774	Mn	6	5	6013.717
b_4 592	Mg	8	3	5167.501	778	Fe	6	8	6024.280
593	–	– d	7	5167.572	782	Fe	7	13	6065.708
594	Fe	6	3	5167.686	786	Ca	6	9	6102.941
b_3 595	Fe	4	3	5169.066	792	Ca	9	11	6122.428
596	–	– d	5	5169.161	797	Ca	10	9	6162.383
597	Fe	4	3	5169.218	804	Fe	8	10	6191.770
b_2 599	Mg	10	9	5172.871	808	Fe, Va	7	12	6230.946
b_1 601	Mg	20	11	5183.792	811	Fe	7	9	6252.776
610	Fe	4	10	5215.352	815	Fe	5	11	6265.347
614	Fe	8	9	5233.124	822	Fe	7	7	6301.719
618	Fe	3	12	5253.649	827	Fe	6	12	6335.550
E_2 630*	Fe	8 d?	16	5269.722	834	Fe	7	9	6393.818
E_1 631	Ca	4		5270.448	838	Fe	7	10	6411.864
632	–	– d	12	5270.495	843	Ca	7	11	6439.298
633	Fe	4		5270.533	846	Ca	5	7	6471.881
639	Fe	6	11	5283.803	850	Fe	7	9	6495.209
643	Fe	4	10	5307.546	856	Ti, Fe	6	11	6546.486
647	Fe	8	8	5324.373	C 858	H	30	13	6563.054
655	Fe	6	8	5367.670	863	Fe	5	11	6593.161
659	Fe	6	11	5383.576	867	Ni	5	10	6643.482
662	Fe	7	14	5405.987	870	Fe	5	10	6678.232
668	Fe	7	9	5347.130	877	Fe	4	12	6750.412
674	Fe	4	10	5463.493	879	Ni	4	9	6768.044
676	Ni	4	10	5477.128	883	Fe	3	8	6810.519
679	Fe	4	8	5501.685	886	Fe	3	6	6441.591
682	Mg	7	8	5528.636	B 896	A(o)	4 d	12	6870.186
687	Fe	5	8	5569.848	911	A(o)	4	13	6884.083
690	Ca	6	9	5588.980	925	A(o)	6	9	6909.675
695	Ca	4	4	5601.501	931	A(o)	4	9	6919.245
699†	Fe	2	12	5624.253	938	A(wv)	8	10	6947.781
700†	Fe, Va	4	14	5624.768	940	A(wv)	8	12	6956.700
706	Fe	5	9	5662.745	957	?	6	8	7035.159
710	Na	6	7	5688.434	961	?	6	5	7122.491
717	Fe	5	10	5731.973	969	A(wv)	10	5	7200.753
720	Fe	5	10	5753.342	977	A(wv)	15	4	7243.904
725	Cu? Co?	7 d?	9	5782.346	984	A(wv)	10	3	7290.714
732	Fe	5	7	5806.954	990	?	7	2	7389.696
737‡	Ca	7	14	5857.672	997‖	A(o)	–	4	7594.059
D_3 740§	He	–	–	5875.982	998	A(o)	10	5	7621.277
D_2 743	Na	15	20	5890.182	1004	A(o)	14	3	7660.778
D_1 745	Na	10	20	5896.154	1010	?	4	1	7714.686

* Component about .088 apart on the photographic plate. It is an exceedingly difficult double.

† Lines used by Pierce in the determination of absolute wave-lengths.

‡ There is a nickel line near to the red.

§ This value of the wave-length is the result of three series of measurements with a grating of 20,000 lines to the inch and is accurate to perhaps .02.

‖ Beginning at the head of *A*, outside edge.

WAVE-LENGTHS OF FRAUNHOFER LINES.

For convenience of reference the values of the wave-lengths corresponding to the Fraunhofer lines usually designated by the letters in the column headed "index letters," are here tabulated separately. The values are in ten millionths of a millimetre on the supposition that the D line value is 5896.156. The table is for the most part taken from Rowland's table of standard wave-lengths, but when no corresponding wave-length is there given, the number given by Kayser and Runge has been taken. These latter are to two places of decimals.

Index letter.	Line due to —	Wave-length in centimetres × 10^8.	Index letter.	Line due to —	Wave-length in centimetres × 10^8.
A	O	7621.277*	G′ or H_γ	H	4340.66 §
	O	7594.059*	G	Fe	4308.071
a	-	7184.781		-	4308.034
B	O	6870.186†		Ca	4307.904
C or H_α	H	6563.054	g	Ca	4226.892
α	O	6278.289‡	h or H_δ	H	4101.87
D_1	Na	5896.154	H	Ca	3968.620
D_2	Na	5890.182	K	Ca	3933.809
D_3	He	5875.982	L	Fe	3820.567
E_1	Fe	5270.533	M	Fe	3727.763
	-	5270.495	N	Fe	3581.344
	Ca	5270.448	O	Fe	3441.135
E_2	Fe	5269.722	P	Fe	3361.30
b_1	Mg	5183.792	Q	Fe	3286.87
b_2	Mg	5172.871	R ‖	Ca	3181.40
b_3	Fe	5169.218		Ca	3179.45
	-	5169.161	v ¶	Fe	3144.58 (?)
	Fe	5169.066	S_1	Fe	3100.779
b_4	Fe	5167.686		Fe	3100.415
	-	5167.572	S_2	Fe	3100.064
	Mg	5167.501	s	Fe	3047.720
F or H_β	H	4861.496	T	Fe	3020.759
d	Fe	4383.721	t	Fe	2994.542
f	Fe	4325.940	U	Fe	2947.993

* The two lines here given for A are stated by Rowland to be: the first, a line "beginning at the head of A, outside edge;" the second, a "single line beginning at the tail of A."
† The principal line in the head of B.
‡ Chief line in the α group.
§ Ames, "Phil. Mag." (5) vol. 30.
‖ Cornu gives 3179.8, which, allowing for the different value of the standard D line, corresponds to about 3180.3.
¶ Cornu gives 3144.7, which would correspond to about 3145.2.

TABLE 181.

DETERMINATIONS OF THE VELOCITY OF LIGHT, BY DIFFERENT OBSERVERS.*

Date of determination.	No. of experiments made.	Method.	Interval worked across in kilometres.	Velocity in kilometres per second.	Velocity in miles per second.	Reference.	Wt. of observation as estimated by Harkness.
1849	–	Toothed wheel	8.633	315324	195935	1	0
1862	80	Revolving mirror	0.02	298574 ± 204	185527 ± 127	2	1
1872	658	Toothed wheel	10.310	298500 ± 995	185481 ± 618	3	1
1874	546	" "	22.91	300400 ± 300	186662 ± 186	4	2
1879	100	Revolving mirror	0.6054	299910 ± 51	186357 ± 31.7	5	3
1880	12	Toothed wheel	{ 5.1313 / 5.5510 }	301384 ± 263	187273 ± 164	6	1
1880 to 1882	148	Revolving mirror	5.1019	299709	186232	7	–
1880 to 1882	39	" "	7.4424	299776	186274	7	–
1880 to 1882	65	" "	7.4424	299860	186326	7	6
1882	23	" "	0.6246	299853 ± 60	186322 ± 37	8	3
Mean from all weighted measurements . .				299835 ± 154	186310 ± 95.6	9	
Mean from those having weights > 1 . . .				299893 ± 23	186347 ± 14.3	9	

1 Fizeau, "Comptes Rendus," 1849.
2 Foucault, "Recueil des travaux scientifiques," Paris, 1878.
3 Cornu, "Jour. de l'Ecole Polytechnique," Paris, 1874.
4 Cornu, "Annales de l'Observatoire de Paris," Memoires, tome 13, p. A. 298, 1876.
5 Michelson, "Proc. A. A. A. S." 1878.
6 Young and G. Forbes, "Phil. Trans." 1882.
7 Newcomb, "Astronomical Papers of the American Ephemeris," vol. 2, pp. 194, 201, and 202.
8 Michelson, "Astronomical Papers of the American Ephemeris," vol. 2, p. 244.
9 Harkness.

TABLE 182.

PHOTOMETRIC STANDARDS.†

Name of standard.	Violle units.	Carcels.	Star candles.	German candles.	English candles.	Hefner-Alteneck lamps.
Violle units ‡	1.000	2.08	16.1	16.4	18.5	18.9
Carcels	0.481	1.00	7.75	7.89	8.91	9.08
Star candles	0.062	0.130	1.00	1.02	1.15	1.17
German candles	0.061	0.127	0.984	1.00	1.13	1.15
English candles	0.054	0.112	0.870	0.886	1.00	1.02
Hefner-Alteneck lamps . .	0.053	0.114	0.853	0.869	0.98	1.00

* Quoted from Harkness, "Solar Parallax," p. 33.
† This table, founded on Violle's experiments, is quoted from Paterson's translation of Palaz' "Industrial Photometry," p. 173.
‡ The Violle unit is sometimes called the absolute standard of white light. It is the quantity of light emitted normally by one square centimetre of the surface of melted platinum at the temperature of solidification.

SOLAR ENERGY AND ITS ABSORPTION BY THE EARTH ATMOSPHERE.

This table gives some of the results of Langley's researches on the atmospheric absorption of solar energy.* The first column gives the wave-length λ, in microns, of the spectrum line, while the second and third columns give the corresponding absorption, according to an arbitrary scale, for high and low solar attitudes. The fourth column, E, gives the relative values of the energy for the different wave-lengths which would be observed were there no terrestrial atmosphere.

λ	a_1	a_2	E
$0^{\mu}.375$	112	27	353
.400	235	63	683
.450	424	140	1031
.500	570	225	1203
.600	621	311	1083
.700	553	324	849
.800	372	246	519
.900	238	167	316
1.000	235	167	309

THE SOLAR CONSTANT.

The "solar constant" is the amount of heat per unit of area of normally exposed surface which, at the earth's mean distance, would be received from the sun's radiation if there were no terrestrial atmosphere. The following table is taken from Langley's researches on the energy of solar radiation.† The first column gives the wave-length in microns. The second and third columns give relatively on an arbitrary scale a upper and a lower limit to the possible value of spectrum energy.

Wave-length.	Spectrum energy (upper limit).	Spectrum energy (lower limit).	Wave-length.	Spectrum energy (upper limit).	Spectrum energy (lower limit).
$0^{\mu}.530$	203.9	122.5	$1^{\mu}.000$	105.0	102.3
.375	196.6	110.0	1.200	78.2	61.3
.400	242.2	139.1	1.400	65.1	52.2
.450	783.2	105.5	1.600	48.0	45.0
.500	852.9	374.1	1.800	39.2	36.4
.600	514.7	333.0	2.000	29.1	27.1
.700	317.7	255.4	2.200	19.4	17.5
.800	173.9	167.3	2.400	7.0	6.8

The areas of the energy curves are respectively . . . 149,060 and 95,933
The solar constants deduced from these areas are . . . 3.505 and 2.630

Langley concludes that "in view of the large limit of error we can adopt *three calories* as the most probable value of the solar constant," or that "at the earth's mean distance, in the absence of its absorbing atmosphere, the solar rays would raise one gramme of water three degrees per minute, for each normally exposed square centimetre of its surface."

* "Am. Jour. of Sci." vols. xxv., xxvii., and xxxii.
† "Professional Papers of U. S. Signal Service," No. 15, 1884.

INDEX OF REFRACTION FOR GLASS.

The table gives the indices of refraction for the Fraunhofer lines indicated in the first column. The kind of glass, the density, and, where known, the corresponding temperature of the glass are indicated at the top of the different columns. When the temperature is not given, average atmospheric temperature may be assumed.

(a) FRAUNHOFER'S DETERMINATIONS. (Ber. Münch. Akad. Bd. 5.)

	Flint glass.		Crown glass.		
Density =	3.723	3.512	2.756	2.535	2.535
Temp. C. =	18°.75	—	—	17°.5	—
B	1.62775	1.60204	1.55477	1.52583	1.52431
C	.62965	.60380	.55593	.52685	.52530
D	.63504	.60849	.55908	.52959	.52798
E	.64202	.61453	.56315	.53301	.53137
F	.64826	.62004	.56674	.53605	.53434
G	.66029	.63077	.57354	.54166	.53991
H	.67106	.64037	.57947	.54657	.54468

(b) BAILLE'S DETERMINATIONS. (Quoted from the Ann. du Bur. des Long. 193, p. 620.)

Flint glass.

Density =	2.98	3.22	3.24	3.44	3.54	3.63	3.68	4.08	5.00
Temp. C. =	23°.2	18°.4	22°.0	19°.5	23°.2	13°.7	24°.0	12°.4	22°.5
B	1.5609	1.5659	1.5766	1.5966	1.6045	1.6131	1.6237	1.6771	1.7801
C	.5624	.5675	.5783	.5982	.6062	.6149	.6255	.6795	.7831
D	.5660	.5715	.5822	.6027	.6109	.6198	.6304	.6858	.7920
b_1	.5715	.5776	.5887	.6098	.6183	.6275	.6384	.6959	.8062
F	.5748	.5813	.5924	.6141	.6225	.6321	.6429	.7019	.8149
G	.5828	.5902	.6018	.6246	.6335	.6435	.6549	.7171	.8368
H	.5898	.5979	.6098	.6338	.6428	.6534	.6647	.7306	.8567

Crown glass. (Baille, *ibid.*)

Density =	2.49	2.50	2.55	2.80	3.00
Temp. C. =	23°.5	17°.8	18°.4	21°.2	21°.9
B	1.5126	1.5244	1.5226	1.5157	1.5554
C	.5134	.5254	.5237	.5166	.5568
D	.5160	.5280	.5265	.5192	.5604
b_1	.5198	.5320	.5307	.5234	.5658
F	.5222	.5343	.5332	.5256	.5690
G	.5278	.5397	.5392	.5313	.5769
H	.5323	.5443	.5442	.5360	.5836

(c) HOPKINSON'S DETERMINATIONS. (Proc. Roy. Soc. vol. 26.)

	Hard crown.	Soft crown.	Titani-silicic crown.	Flint glass.				
Density =	2.486	2.550	2.553	2.866	3.206	3.659	3.889	4.422
A	1.511755	1.508956	–	1.534067	–	–	1.639143	1.696531
B	.513625	.510916	1.539155	.536450	1.568558	1.615701	.642874	.701060
C	.514568	.511904	.540255	.537673	.570011	.617484	.644866	.703478
D	.517114	.514591	.543249	.541011	.574015	.622414	.650388	.710201
E	.520331	.518010	.547088	.545306	.579223	.628895	.657653	.719114
b_1	.520967	.518686	.547852	.546166	.580271	.630204	.659122	.720924
F	.523139	.520996	.550471	.549121	.583886	.634748	.664226	.727237
(G)	.527994	.526207	.556386	.555863	.592190	.645267	.676111	.742063
G	.528353	.526595	.556830	.556372	.592824	.646068	.677019	.743204
h	.530902	.529359	.559999	.560010	.597332	.651840	.683577	.751464
H_1	.532792	.531416	.562392	.562760	.600727	.656219	.688569	.757785

N. B. — D is the more refrangible of the pair of sodium lines; (G) is the hydrogen line near G.

INDEX OF REFRACTION FOR GLASS.

(d) MASCART'S DETERMINATIONS. (Ann. Chim. Phys. 1868.)

	Flint glass.		Crown glass.
Density =	3.615	3.239	2.578
Temp. =	30°.0	26°.0	28°.0
A	1.60927	1.57829	1.52814
B	.61268	.58114	.53011
C	.61443	.58261	.53113
D	.61929	.58671	.53386
E	.62569	.59197	.53735
b_4	.62706	.59304	.53801
F	.63148	.59673	.54037
G	.64269	.60589	.54607
H	.65268	.61390	.55093
L	.65817	.62012	.55349
M	.66211	.62138	.55531
N	.66921	.62707	.55853
O	.67733	.63341	.56198
P	–	.63754	.56419
Q	–	.64174	.56646

(e) LANGLEY'S DETERMINATIONS. (Silliman's Journal, 27, 1884.)

Flint glass.	
Wave length in mm. × 10^6.	Index of refraction.
2030	1.5515
1918	.5520
1870	.5535
1810	.5544
1580	.5572
1540	.5576
1360	.5604
1270	.5616
1130	.5636
940	.5668
910	.5674
890	.5678
850	.5687
815	.5697
760.1 = A	.5714
656.2 = C	.5757
588.9 = D_1	.5798
516.7 = b_4	.5862
486.1 = F	.5899
396.8 = H_1	.6070
344.0 = O	.6266

(f) EFFECT OF TEMPERATURE. (Vogel, Wied. Ann. vol. 25.)

$$n_t + n_{t'} = \alpha(t - t') + \beta(t - t')^2,$$

where n_t is the absolute index of refraction for the temperature t, and α and β are constants. For temperatures ranging from 12° to 260° Vogel obtains the following values of α and β for the Fraunhofer lines given at the tops of the columns.

		H_α	D	H_β	H_γ
White glass	$\alpha . 10^8 =$	96	123	224	327
	$\beta . 10^{10} =$	107	106	97	93
Flint glass	$\alpha . 10^8 =$	190	190	362	575
	$\beta . 10^{10} =$	101	147	221	221

(g) EFFECT OF TEMPERATURE. (Müller, Publ. d. Astrophys. Obs. zu Potsdam, 1885.)

Fraunhofer line.	Flint glass.		Crown glass.
	Density = 3.855. Temp. C. = − 1° to 24°.	Density = 3.218. Temp. C. = − 3° to 21°.	Density = 2.522. Temp. C. = − 5° to 23°.
B	1.643776 + .00000474 t	1.574359 + .00000324 t	1.512588 — .00000043 t
C	.645745 + .00000486 t	.575828 + .00000333 t	.513558 — .00000033 t
D	.651193 + .00000495 t	.579856 + .00000323 t	.516149 + .00000017 t
b_1	.659632 + .00000710 t	.586000 + .00000443 t	.520004 + .00000054 t
F	.664936 + .00000653 t	.589828 + .00000439 t	.522349 + .00000048 t
H_γ	.676720 + .00000783 t	.598205 + .00000560 t	.527360 + .00000082 t
h	.684144 + .00000861 t	.603398 + .00000636 t	.520376 + .00000143 t

N. B. — The above examples on the effect of temperature give an idea of the order of magnitude of that effect, but are only applicable to the particular specimens experimented on.

INDEX OF REFRACTION.

Indices of Refraction for the various Alums.*

R	Density.	Temp. C°	a	B	C	D	E	b	F	G
			Aluminium Alums. $R\mathrm{Al(SO_4)_2+12H_2O}$.†							
Na	1.667	17–28	1.43492	1.43563	1.43653	1.43884	1.44185	1.44231	1.44412	1.44804
$NH_3(CH_3)$	1.568	7–17	.45013	.45062	.45177	.45410	.45691	.45749	.45941	.46363
K	1.735	14–15	.45226	.45303	.45398	.45645	.45934	.45996	.46181	.46609
Rb	1.852	7–21	.45232	.45328	.45417	.45660	.45955	.45999	.46192	.46618
Cs	1.961	15–25	.45437	.45517	.45618	.45856	.46141	.46203	.46386	.46821
NH_4	1.631	15–20	.45509	.45599	.45693	.45939	.46234	.46288	.46481	.46923
Te	2.329	10–23	.49226	.49317	.49443	.49748	.50128	.50209	.50463	.51076
			Indium Alums. $R\mathrm{In(SO_4)_2+12H_2O}$.†							
Rb	2.065	3–13	1.45942	1.46024	1.46126	1.46381	1.46694	1.46751	1.46955	1.49402
Cs	2.241	17–22	.46091	.46170	.46283	.46522	.46842	.46897	.47105	.47562
NH_4	2.011	17–21	.46193	.46259	.46352	.46636	.46953	.47015	.47234	.47750
			Gallium Alums. $R\mathrm{Ga(SO_4)_2+12H_2O}$.†							
Cs	2.113	17–22	1.46047	1.46146	1.46243	1.46495	1.46785	1.46841	1.47034	1.47481
K	1.895	19–25	.46118	.46195	.46296	.46528	.46842	.46904	.47093	.47548
Rb	1.962	13–15	.46152	.46238	.46332	.46579	.46890	.46930	.47126	.47581
NH_4	1.777	15–21	.46390	.46485	.46575	.46835	.47146	.47204	.47412	.47864
Te	2.477	18–20	.50112	.50228	.50349	.50665	.51057	.51131	.51387	.52007
			Chrome Alums. $R\mathrm{Cr(SO_4)_2+12H_2O}$.†							
Cs	2.043	6–12	1.47627	1.47732	1.47836	1.48100	1.48434	1.48491	1.48723	1.49280
K	1.817	6–17	.47642	.47738	.47865	.48137	.48459	.48513	.48753	.49309
Rb	1.946	12–17	.47660	.47756	.47868	.48151	.48486	.48522	.48775	.49323
NH_4	1.719	7–18	.47911	.48014	.48125	.48418	.48744	.48794	.49040	.49594
Te	2.386	9–25	.51692	.51798	.51923	.52280	.52704	.52787	.53082	.53808
			Iron Alums. $R\mathrm{Fe(SO_4)_2+12H_2O}$.†							
K	1.806	7–11	1.47639	1.47706	1.47837	1.48169	1.48580	1.48670	1.48939	1.49605
Rb	1.916	7–20	.47700	.47770	.47894	.48234	.48654	.48712	.49003	.49700
Cs	2.061	20–24	.47825	.47921	.48042	.48378	.48797	.48867	.49136	.49838
NH_4	1.713	7–20	.47927	.48029	.48150	.48482	.48921	.48993	.49286	.49980
Te	2.385	15–17	.51674	.51790	.51943	.52365	.52859	.52946	.53284	.54112

* According to the experiments of Soret (Arch. d. Sc. Phys. Nat. Genève, 1884, 1888, and Comptes Rendus, 1885).
† *R* stands for the different bases given in the first column.

INDEX OF REFRACTION.

Index of Refraction of Metals and Metallic Oxides.

(a) Experiments of Kundt* by transmission of light through metallic prisms of small angle.

Name of substance.	Index of refraction for Red.	White.	Blue.
Silver	–	0.27	–
Gold	0.38	0.58	1.00
Copper	0.45	0.65	0.95
Platinum	1.76	1.64	1.44
Iron	1.81	1.73	1.52
Nickel	2.17	2.01	1.85
Bismuth	2.61	2.26	2.13
Gold and gold oxide	1.04	–	1.25
" " "	0.89	0.99	1.33
" " " †	–	2.03	–
Bismuth oxide	–	1.91	–
Iron oxide	1.78	2.11	2.36
Nickel oxide	2.18	2.23	2.39
Copper oxide	2.63	2.84	3.18
Platinum and platinum oxide	3.31	3.29	2.90
" " "	4.99	4.82	4.40

(b) Experiments of Du Bois and Rubens by transmission of light through prisms of small angle.

The experiments were similar to those of Kundt, and were made with the same spectrometer. Somewhat greater accuracy is claimed for these results on account of some improvements introduced, mainly by Prof. Kundt, into the method of experiment. There still remains, however, a somewhat large chance of error.

Name of metal.	Index of refraction for light of the following color and wave-length.				
	Red (Li_a). $\lambda = 67.1$	"Red." $\lambda = 64.4$	Yellow (D). $\lambda = 58.9$	Blue (F). $\lambda = 48.6$	Violet (G). $\lambda = 43.1$ ‡
Nickel	2.04	1.93	1.84	1.71	1.54
Iron	3.12	3.06	2.72	2.43	2.05
Cobalt	3.22	3.10	2.76	2.39	2.10

(c) Experiments of Drude.

The following table gives the results of some of Drude's experiments.§ The index of refraction is derived in this case from the constants of elliptic polarization by reflection, and are for sodium light.

Metal.	Index of refraction.	Metal.	Index of refraction.
Aluminium	1.44	Mercury	1.73
Antimony	3.04	Nickel	1.79
Bismuth	1.90	Platinum	2.06
Cadmium	1.13	Silver	0.181
Copper	0.641	Steel	2.41
Gold	0.366	Tin, solid	1.48
Iron	2.36	" fluid	2.10
Lead	2.01	Zinc	2.12
Magnesium	0.37		

* "Wied. Ann." vol. 34, and "Phil. Mag." (5) vol. 26.
‡ Wave-lengths λ are in millionths of a centimetre.
† Nearly pure oxide.
§ "Wied. Ann." vol. 39.

INDEX OF REFRACTION.

TABLE 188. — Index of Refraction of Rock Salt.

Determined by Langley. Temp. 24° C.

Line of spectrum.	Wave-length in cms. × 10⁶.	Index of refraction.
M	37.27	1.57486
L	38.20	.57207
H_2	39.33	.56920
H_1	39.68	.56833
G	43.03	.56133
F	48.61	.55323
b_4	51.67	.54991
b_1	51.83	.54975
D_1	57.89	.54418
D_2	58.95	.54414
C	65.62	.54051
B	68.67	.53919
A	76.01	.5367
$\rho \sigma \tau$	94.	.5328
ϕ	113.	.5305
Ψ	139.	.5287
Ω	132.	.5268

Determined by Baden Powell.

Line of spectrum.	Wave-length in cms. × 10⁶.	Index of refraction.
B	-	1.5403
C	-	.5415
D	-	.5448
E	-	.5498
F	-	.5541
G	-	.5622
H	-	.5691

Determined by Rubens and Snow.

Line of spectrum.	Wave-length in cms. × 10⁶.	Index of refraction.
H_γ	43.4	1.5607
F	48.5	.5531
D	58.9	.5441
C	65.6	.5404
	75.5	.5370
	79.0	.5358
	83.1	.5347
	87.6	.5337
	92.3	.5329
	97.8	.5321
	103.5	.5313
	110.7	.5305
	118.6	.5299
	127.7	.5293
	138.4	.5286
	151.1	.5280
	166.0	.5275
	184.5	.5270
	207.6	.5264
	237.2	.5257
	277.1	.5247
	302.2	.5239
	332.0	.5230
	369.0	.5217
	415.0	.5208
	474.5	.5197
	554.0	.5184
	644.7	.5163
	830.7	.5138

Determined by other authorities.

Line of spectrum.	Index of refraction.	Authority.
H_α	1.54046	Haagen at 20° C.
H_β	.55319	
H_γ	.56056	
H_α	1.54095	Bedson and Carleton Williams at 15° C.
H_β	.55384	
H_γ	.52515	
B	1.53884	Mülheims.
C	.54016	
D	.54381	
E	.54866	
F	.55280	
A	1.53663	Stefan at 17° and 22° C. The upper values are at 17° and the lower at 22° for each line.
B	.53918	
	.53902	
C	.54050	
	.54032	
D	.54418	
	.54400	
E	.54901	
	.54882	
F	.55324	
	.55304	
G	.56129	
	.56108	
H	.56823	
	.56806	

TABLE 189. — Index of Refraction of Sylvine (Potassium Chloride).

Determined by Rubens and Snow: Wave-length in cms. × 10⁶.	Index of refraction.	Wave-length in cms. × 10⁶.	Index of refraction.	Determined by other authorities: Line of spectrum.	Index of refraction.	Authority.
43.4 (H_γ)	1.5048	145.8	1.4766	A	1.48377	Stefan at 20 C.
48.6 (F)	.4981	160.3	.4761	B	.48597	
58.9 (D)	.4900	178.1	.4755	C	.48713	
65.6 (C)	.4868	200.5	.4749	D	.49031	
				E	.49455	
80.2	1.4829	229.1	1.4742	F	.49830	
84.5	.4819	267.3	.4732	G	.50542	
89.3	.4809	320.9	.4722	H	.51061	
94.4	.4807	356.1	.4717	B	.4754	Grailich.
				C	.4767	
100.3	1.4795	400.1	1.4712	D	.4825	
107.0	.4789	457.7	.4708	E	.4877	
114.5	.4781	534.5	.4701	F	.4903	
123.4	.4776	641.2	.4693	G	.5005	
				D	.4904	Tschermak.
1337	1.4771	802.2	1.4681	D	.4930	Groth.

INDEX OF REFRACTION.

Index of Refraction of Fluor-Spar.

Determined by Rubens and Snow.		Determined by Sarasin.			Determined by the authorities quoted.		
Wave-length in cms. $\times 10^6$.	Index of refraction.	Line of spectrum.	Wave-length in cms. $\times 10^6$.	Index of refraction.	Line of spectrum.	Index of refraction.	Authority.
43.4($H\gamma$)	1.4393	A	76.040	1.431010	D	1.4339	Fizeau.
48.5(F)	.4372	a	71.836	.431575			
58.9(D)	.4340	B	68.671	.431997	A	1.43003	Mülheims.
65.6(C)	.4325	c	65.618	.432571	a	.43153	Mülheims.
80.7	.4307	D	58.920	.433937	B	.43200	Mülheims.
85.0	.4303	F	48.607	.437051	c	.43250	Mülheims.
89.6	.4299	h	41.012	.441215	D	.43384	Mülheims.
95.0	.4294	H	39.681	.442137	E	.43551	Mülheims.
100.9	.4290	Cd	36.090	.445356	F	.43696	Mülheims.
107.6	.4286	"	34.655	.446970			
115.2	.4281	"	34.015	.447754	B	1.43200	Stefan.
124.0	.4277	"	32.525	.449871	D	.43390	Stefan.
134.5	.4272	"	27.467	.459576	F	.43709	Stefan.
146.6	.4267	"	25.713	.464760	G	.43982	Stefan.
161.3	.4260	"	23.125	.475166	H	.44204	Stefan.
179.2	.4250	"	22.645	.477622			
201.9	.4240	"	21.935	.481515	Red	1.433	DesCloiseaux.
230.3	.4224	"	21.441	.484631	Yellow	.435	DesCloiseaux.
268.9	.4205	Zn	20.988	.487655			
322.5	.4174	"	20.610	.490406	Na	1.4324*	Kohlrausch.
403.5	.4117	"	20.243	.493256	"	.4342†	Kohlrausch.
462.0	.4080	Al	19.881	.496291			
538.0	.4030	"	19.310	.502054			
646.0	.3960	"	18.560	.509404			
807.0	.3780						

* Gray at 23° C.
† Black at 19° C.

INDEX OF REFRACTION.

Various Monorefringent or Optically Isotropic Solids.

Substance.	Line of Spectrum.	Index of Refraction.	Authority.
Agate (light color)	red	1.5374	De Senarmont.
Ammonium chloride	D	1.6422	Grailich.
Arsenite	D	1.755	DesCloiseaux.
Barium nitrate	D	1.5716	Fock.
Bell metal	D	1.0052	Beer.
Blende	Li	2.34165	Ramsay.
	Na	2.36923	
	Tl	2.40069	
Boric acid	C	1.46245	Bedson and Carleton Williams.
	D	1.46303	
	F	1.47024	
Borax (vitrified)	C	1.51222	
	D	1.51484	
	F	1.52068	
Camphor	D	1.532	Kohlrausch.
		1.5462	Mulheims.
Diamond (colorless)	red	2.414	DesCloiseaux.
	green	2.428	
Diamond (brown)	B	2.46062	Schrauf.
	D	2.46986	
	E	2.47902	
Ebonite	D	1.6	Ayrton & Perry.
Fuchsin	A	1.73	Wernicke.
	B	1.81	
	C	1.90	
	G	1.31	
	H	1.54	
Garnet (different varieties)	D	1.74 to 1.90	Various.
Gum arabic	red	1.480	Jamin.
" "	"	1.514	Wollaston.
Hanyne	D	1.4961	Tschichatscheff.
Helvine	D	1.739	Levy & Lecroix.
Obsidian	D	1.482 to 1.486	Various.
Opal	D	1.406 1.450	"
Pitch	red	1.531	Wollaston.
Potassium bromide	D	1.5593	Topsöe and Christiansen.
" chlorstannate	"	1.6574	
" iodide	"	1.6666	
Phosphorus	"	2.1442	Gladstone & Dale.
Resins: Aloes	red	1.619	Jamin.
Canada balsam	"	1.528	Wollaston.
Colophony	"	1.548	Jamin.
Copal	"	1.528	"
Mastic	"	1.535	Wollaston.
Peru balsam	D	1.593	Baden Powell.
Selenium, vitreous	A	2.653	Sirks.
	B	2.730	
	C	2.86	
	D	2.98	
Silver bromide	D	2.533	Wernicke.
Silver chloride	"	2.061	
Silver iodide	"	2.182	
Sodalite blue	"	1.4827	Feusner.
Sodalite clear like water	"	1.4833	
Sodium chlorate	"	1.5150	Dussaud.
Spinel	"	1.7155	DesCloiseaux.
Strontium nitrate	"	1.5667	Fock.

INDEX OF REFRACTION.

Index of Refraction of Iceland Spar.

The determinations of Carvallo, Mascart, and Sarasin cover a considerable range of wave-length, and are here given. Many other determinations have been made, but they differ very little from those quoted.

Line of spectrum.	Wave-length in cms. × 10^6.	Index of refraction for — Ordinary ray.	Extraordinary ray.
Authority: Carvallo.			
-	215	-	1.4753
-	198	1.6279	-
-	177	-	.4766
-	154	.6350	-
-	145	.6361	.4779
-	122	.6403	-
-	108	.6424	.44799
A	76.04	.65006	.48275
B	68.67	.65293	.48406
Authority: Sarasin.			
A	76.04	1.65000	1.48261
a	71.84	.65156	.48336
B	68.67	.65285	.48391
Cd_1	64.37	.65501	.48481
D	58.92	.65839	.48644
Cd_2	53.77	.66234	.48815
Cd_3	53.36	.66274	.48843
Cd_4	50.84	.66525	.48953
F	48.61	.66783	49079
Cd_5	47.99	.66858	.49112
Cd_6	46.76	.67023	.49185
Cd_7	44.14	.67417	.49367
h	41.01	.68036	.49636
H	39.68	.68319	.49774
Cd_9	36.09	.69325	.50228
Cd_{10}	34.65	.69842	.50452
Cd_{11}	34.01	.70079	.50559
Cd_{12}	32.53	1.70740	1.50857
Cd_{17}	27.46	.74151	.52276
Cd_{18}	25.71	.76050	.53019
Cd_{23}	23.12	.80248	.54559
Cd_{24}	22.64	.81300	.54920
Cd_{25}	21.93	.83090	.55514
Cd_{26}	21.43	.84580	.55993
Authority: Mascart.			
A	-	1.65013	1.48285
a	-	.65162	-
B	-	.65296	.48409
C	-	.65446	.48474
D	-	.65846	.48654
E	-	.66354	.48885
b_4	-	.66446	-
F	-	.66793	.49084
G	-	.67620	.49470
H	-	.68330	.49777
L	-	.68706	.49941
M	-	.68966	.50054
N	-	.69441	.50256
O	-	.69955	.50486
P	-	.70276	.50628
Q	-	.70613	.50780
R	-	.71155	.51028
S	-	.71580	-
T	-	.71939	-

INDEX OF REFRACTION.

Index of Refraction of Quartz.

Line or wave-length in cms. × 10⁶.	Index for —	
	Ordinary ray.	Extraordinary ray.
Authority: Sarasin.*		
Cd_1	1.54227	1.55124
D	.54419	.55335
Cd_2	.54655	.55573
Cd_3	.54675	.55595
Cd_4	.54825	.55749
Cd_5	.55014	.55943
Cd_6	.55104	.56038
Cd_7	.55318	.56270
Cd_9	.56348	.57319
Cd_{10}	.56617	.57599
Cd_{11}	.56744	.57741
Cd_{12}	.57094	.58097
Cd_{17}	.58750	.59812
Cd_{18}	.59624	.60713
Cd_{23}	.61402	.62561
Cd_{24}	.61816	.62992
Cd_{25}	.62502	.63705
Cd_{26}	.63040	.64268
Zn_{27}	.63569	.64813
Zn_{28}	.64041	.65308
Zn_{29}	.64566	.65852
Al_{30}	.65070	.66410
Al_{31}	.65990	.67410
Al_{32}	.67500	.68910
Authority: Rubens.		
43.4(H_γ)	1.5538	–
48.5(F)	.5499	–
59.0(G)	.5442	–
65.6(C)	.5419	–
83.9	.5376	–
90.4	.5364	–
97.9	.5353	–
106.7	.5342	–
117.4	.5325	–
130.5	.5310	–
146.8	.5287	–
167.9	.5257	–
195.7	.5216	–
234.8	.5160	–

Line of spectrum.	Index for —	
	Ordinary ray.	Extraordinary ray.
Quincke (right-handed quartz).		
B	1.53958	1.54780
C	.54087	.54933
D	.54335	.55199
E	.54649	.55508
F	.54868	.55758
G	.55241	.56193
Quincke (left-handed quartz).		
B	1.54022	1.54880
C	.54092	.54945
D	.54318	.55245
E	.54575	.55533
F	.54845	.55801
G	.55246	.56163
Authority: Mascart.		
A	1.53902	1.54812
a	54018	.54919
B	.54099	.55002
C	.54188	.55095
D	.54423	.55338
E	.54718	.55636
b_4	.54770	.55694
F	.54966	.55897
G	.55429	.56372
H	.55816	.56770
L	.56019	.56974
M	.56150	.57121
N	.56400	.57381
O	.56668	.57659
P	.56842	.57822
Q	–	.57998
R	–	.58273
Authority: Van der Willigen (left-handed quartz).		
A	1.53914	1.54806
B	.54097	.54998
C	.54185	.55085
D	.54419	.55329
E	.54715	.55633
F	.54966	.55855
G	.55422	.56365
H	.55811	.56769

* For wave-lengths, see Tables 190 and 192.

INDEX OF REFRACTION.

TABLE 194. — Uniaxial Crystals.

Substance.	Line of spectrum.	Index of refraction. Ordinary ray.	Extraordinary ray.	Authority.
Alunite (alum stone)	D	1.573	1.592	Levy & Lacroix.
Ammonium arseniate	red	1.577	4.524	De Senarmont.
Anatase	D	2.5354	2.4959	Schrauf.
Apatite	D	1.6390	1.6345	"
Benzil	D	1.6588	1.6784	DesCloiseaux.
Beryl	D	1.589 to 1.570	1.582 to 1.566	Various.
Brucite	D	1.560	1.581	Kohlrausch.
Calomel	red	1.96	2.60	De Senarmont.
Cinnabar	red	2.854	3.199	DesCloiseaux.
Corundum (ruby, sapphire, etc.)	red	1.767 to 1.769	1.759 1.762	"
Dioptase	green	1.667	1.723	"
Emerald (pure)	green	1.584	1.578	"
Ice at — 8° C.	D	1.309	1.313	Meyer.
Idocrase	D	1.719 to 1.722	1.717 to 1.720	DesCloiseaux.
Ivory	D	1.539	1.541	Kohlrausch.
Magnesite	D	1.717	1.515	Mallard.
Potassium arseniate	red	1.564	1.515	DesCloiseaux.
" "	red	1.493	1.501	De Sernamont.
Silver (red ore)	red	3.084	2.881	Fizeau.
Sodium arseniate	D	1.459	1.467	Baker.
" nitrate	D	1.587	1.336	Schrauf.
" phosphate	D	1.446	2.452	Dufet.
Strychnine sulphate	D	1.614	1.519	Martin.
Tin stone	D	1.997	2.093	Grubenman.
Tourmaline (colorless)	D	1.637	1.619	Heusser.
" (different colors)	D	1.633 to 1.650	1.616 to 1.625	Jeroféjew.
Zircon (hyacinth)	red	1.92	1.97	De Senarmont.
" "	D	1.924	1.968	Sanger.

TABLE 195. — Biaxial Crystals.

Substance.	Line of spectrum.	Index of refraction. Minimum.	Intermediate.	Maximum.	Authority.
Anglesite	D	1.8771	1.8823	1.8936	Arzruni.
Anhydrite	D	1.5693	1.5752	1.6130	Mülheims.
Antipyrin	D	1.5101	1.6812	1.6858	Glazebrook.
Aragonite	D	1.5301	1.6816	1.6859	Rudberg.
Axinite	red	1.6720	1.6779	1.6810	DesCloiseaux.
Barite	D	1.636	1.637	1.648	Various.
Borax	D	1.4467	1.4694	1.4724	Dufet.
Copper sulphate	D	1.5140	1.5368	1.5433	Kohlrausch.
Gypsum	D	1.5208	1.5228	1.5298	Mülheims.
Mica (muscovite)	D	1.5601	1.5936	1.5977	Pulfrich.
Olivine	D	1.661	1.678	1.697	DesCloiseaux.
Orthoclase	D	1.5190	1.5237	1.5260	"
Potassium bichromate	D	1.7202	1.7380	1.8197	Dufet.
" nitrate	D	1.3346	1.5056	1.5064	Schrauf.
" sulphate	D	1.4932	1.4946	1.4980	Topsöe & Christiansen.
Sugar (cane)	D	1.5397	1.5667	1.5716	Calderon.
Sulphur (rhombic)	D	1.9505	2.0383	2.2405	Schrauf.
Topaz (Brazilian)	D	1.6294	1.6308	1.6375	Mülheims.
Topaz (different kinds)	D	1.630 to 1.613	1.631 to 1.616	1.637 to 1.623	Various.
Zinc sulphate	D	1.4568	1.4801	1.4836	Topsöe & Christiansen.

INDEX OF REFRACTION.

Indices of Refraction relative to Air for Solutions of Salts and Acids.

Substance.	Density.	Temp. C.	Indices of refraction for spectrum lines. C	D	F	H_γ	H	Authority.
			(a) SOLUTIONS IN WATER.					
Ammonium chloride	1.067	27°.05	1.37703	1.37936	1.38473	–	1.39336	Willigen.
" "	.025	29.75	.34850	.35050	.35515	–	.36243	"
Calcium chloride .	.398	25.65	.44000	.44279	.44938	–	.46001	"
" "	.215	22.9	.39411	.39652	.40206	–	.41078	"
" "	.143	25.8	.37152	.37369	.37876	–	.38666	"
Hydrochloric acid .	1.166	20.75	1.40817	1.41109	1.41774	–	1.42816	"
Nitric acid	.359	18.75	.39893	.40181	.40857	–	.41961	"
Potash (caustic) . .	.416	11.0	.40052	.40281	.40808	–	.41637	Fraunhofer.
Potassium chloride .	normal	solution	.34087	.34278	.34719	1.35049	–	Bender.
" "	double	normal	.34982	.35179	.35645	.35994	–	"
" "	triple	normal	.35831	.36029	.36512	.36890	–	"
Soda (caustic) . .	1.376	21.6	1.41071	1.41334	1.41936	–	1.42872	Willigen.
Sodium chloride . .	.189	18.07	.37562	.37789	.38322	1.38746	–	Schutt.
" "	.109	18.07	.35751	.35959	.36442	.36823	–	"
" "	.035	18.07	.34000	.34191	.34628	.34969	–	"
Sodium nitrate . .	1.358	22.8	1.38283	1.38535	1.39134	–	1.40121	Willigen.
Sulphuric acid . .	.811	18.3	.43444	.43669	.44168	–	.44883	"
" "	.632	18.3	.42227	.42466	.42967	–	.43694	"
" "	.221	18.3	.36793	.37009	.37468	–	.38158	"
" "	.028	18.3	.33663	.33862	.34285	–	.34938	"
Zinc chloride . . .	1.359	26.6	1.39977	1.40222	1.40797	–	1.41738	"
" " . . .	.209	26.4	.37292	.37515	.38026	–	.38845	"
			(b) SOLUTIONS IN ETHYL ALCOHOL.					
Ethyl alcohol . . .	0.789	25.5	1.35791	1.35971	1.36395	–	1.37094	Willigen.
" "	.932	27.6	.35372	.35556	.35986	–	.36662	"
Fuchsin (nearly saturated)	–	16.0	.3918	.398	.361	–	.3759	Kundt.
Cyanin (saturated) .	–	16.0	.3831	–	.3705	–	.3821	"

NOTE. — Cyanin in chloroform also acts anomalously; for example, Sieben gives for a 4.5 per cent. solution $\mu_A = 1.4593$, $\mu_B = 1.4695$, μ_F(green) $= 1.4514$, μ_G (blue) $= 1.4554$. For a 9.9 per cent. solution he gives $\mu_A = 1.4902$, μ_F(green) $= 1.4497$, μ_G(blue) $= 1.4597$.

(c) SOLUTIONS OF POTASSIUM PERMANGANATE IN WATER.*

Wave-length in cms. $\times 10^6$.	Spectrum line.	Index for 1 % sol.	Index for 2 % sol.	Index for 3 % sol.	Index for 4 % sol.	Wave-length in cms. $\times 10^6$.	Spectrum line.	Index for 1 % sol.	Index for 2 % sol.	Index for 3 % sol.	Index for 4 % sol.
68.7	B	1.3328	1.3342	–	1.3382	51.6	–	1.3368	1.3385	–	–
65.6	C	.3335	.3348	1.3365	.3391	50.0	–	.3374	.3383	1.3386	1.3404
61.7	–	.3343	.3365	.3381	.3410	48.6	F	.3377	–	–	.3408
59.4	–	.3354	.3373	.3393	.3426	48.0	–	.3381	.3395	.3398	.3413
58.9	D	.3353	.3372	–	.3426	46.4	–	.3397	.3402	.3414	.3423
56.8	–	.3362	.3387	.3412	.3445	44.7	–	.3407	.3421	.3426	.3439
55.3	–	.3366	.3395	.3417	.3438	43.4	–	.3417	–	–	.3452
52.7	E	.3363	–	–	–	42.3	–	.3431	.3442	.3457	.3468
52.2	–	.3362	.3377	.3388	–	–	–	–	–	–	–

* According to Christiansen.

INDEX OF REFRACTION.

Indices of Refraction of Liquids relative to Air.

Substance.	Temp. C.	Index of refraction for spectrum lines.					Authority.
		C	D	F	H_γ	H	
Acetone	10°	1.3626	1.3646	1.3694	1.3732	–	Korten.
Almond oil . . .	0	.4755	.4782	.4847	–	–	Olds.
Analin *	20	.5993	.5863	.6041	.6204	–	Weegmann.
Aniseed oil . . .	21.4	.5410	.5475	.5647	–	–	Willigen.
" " . . .	15.1	.5508	.5572	.5743	–	1.6084	Baden Powell.
Benzene †	10	1.4983	1.5029	1.5148	–	1.5355	Gladstone.
"	21.5	.4934	.4979	.5095	–	.5304	"
Bitter almond oil .	20	.5391	–	.5623	.5775	–	Landolt.
Bromnaphtalin . .	20	.6495	.6582	.6819	.7041	.7289	Walter.
Carbon disulphide ‡	0	1.6336	1.6433	1.6688	1.6920	1.7175	Ketteler.
" "	20	.6182	.6276	.6523	.6748	.6994	"
" "	10	.6250	.6344	.6592	–	.7078	Gladstone.
" "	19	.6189	.6284	.6352	–	.7010	Dufet.
Cassia oil	10	.6007	.6104	.6389	–	.7039	Baden Powell.
" "	22.5	.5930	.6026	.6314	–	.6985	" "
Chinolin	20	1.6094	1.6171	1.6361	1.6497	–	Gladstone.
Chloroform . . .	10	.4466	.4490	.4555	–	.4661	Gladstone & Dale.
" . . .	30	–	.4397	–	–	.4561	" "
" . . .	20	.4437	.4462	.4525	–	–	Lorenz.
Cinnamon oil . .	23.5	.6077	.6188	.6508	–	–	Willigen.
Ether	15	1.3554	1.3566	1.3606	–	1.3683	Gladstone & Dale.
"	15	.3573	.3594	.3641	–	.3713	Kundt.
Ethyl alcohol . .	0	.3677	.3695	.3739	.3773	–	Korten.
" " . .	10	.3636	.3654	.3698	.3732	–	"
" " . .	20	.3596	.3614	.3657	.3690	–	"
" " . .	15	.3621	.3638	.3683	–	.3751	Gladstone & Dale.
Glycerine	20	1.4706	–	1.4784	1.4828	–	Landolt.
Methyl alcohol . .	15	.3308	1.3326	.3362	–	.3421	Baden Powell.
Olive oil	0	.4738	.4763	.4825	–	–	Olds.
Rock oil	0	.4345	.4573	.4644	–	–	"
Turpentine oil . .	10.6	1.4715	1.4744	1.4817	–	1.4939	Fraunhofer.
" " . .	20.7	.4692	.4721	.4793	–	.4913	Willigen.
Toluene	20	.4911	.4955	.5070	.5170	–	Bruhl.
Water §	16	.3318	.3336	.3377	.3409	–	Dufet.
"	16	.3318	.3337	.3378	–	.3442	Walter.

* Weegmann gives $\mu_D = 1.59668 - .000518\,t$. Knops gives $\mu_F = 1.61500 - .00056\,t$.

† Weegmann gives $\mu_D = 1.51474 - .000665\,t$. Knops gives $\mu_D = 1.51399 - .000644\,t$.

‡ Wüllner gives $\mu_C = 1.63407 - .00078\,t$; $\mu_F = 1.66908 - .00082\,t$; $\mu_h = 1.69215 - .00085\,t$.

§ Dufet gives $\mu_D = 1.33397 - 10^{-7}(125\,t + 20.6\,t^2 - .000435\,t^3 - .00115\,t^4)$ between 0° and 50°; and nearly the same variation with temperature was found by Ruhlmann, namely, $\mu_D = 1.33373 - 10^{-7}(20.14\,t^2 + .000494\,t^4)$.

INDEX OF REFRACTION.

Indices of Refraction of Gases and Vapors.

A formula was given by Biot and Arago expressing the dependence of the index of refraction of a gas on pressure and temperature. More recent experiments confirm their conclusions. The formula is $n_t - 1 = \frac{n_0 - 1}{1 + \alpha t} \cdot \frac{p}{760}$, where n_t is the index of refraction for temperature t, n_0 for temperature zero, α the coefficient of expansion of the gas with temperature, and p the pressure of the gas in millimetres of mercury. Taking the mean value, for air and white light, of $n_0 - 1$ as 0.0002936 and α as 0.00367 the formula becomes

$$n_t - 1 = \frac{.0002936}{1 + .00367\,t} \cdot \frac{P}{1.0136 \times 10^6} = \frac{.0002895}{1 + .00367\,t}\,\frac{P}{10^6}$$

where P is the pressure in dynes per square centimetre, and t the temperature in degrees Centigrade.

(a) The following table gives some of the values obtained for the different Fraunhofer lines for air.

Spectrum line.	Index of refraction according to — Ketteler.	Lorenz.	Kayser & Runge.	Spectrum line.	Index of refraction according to Kayser & Runge.
A	1.0002929	1.0002893	1.0002905	M	1.0002993
B	2935	2899	2911	N	3003
C	2938	2902	2914	O	3015
D	2947	2911	2922		
E	2958	2922	2933	P	1.0003023
				Q	3031
F	1.0002968	1.0002931	1.0002943	R	3043
G	2987	2949	2962		
H	3003	2963	2978	S	1.0003053
K	–	–	2980	T	3064
L	–	–	2987	U	3075

(b) The following data have been compiled from a table published by Brühl (Zeits. für Phys. Chem. vol. 7, pp. 25-27). The numbers are from the results of experiments by Biot and Arago, Dulong, Jamin, Ketteler, Lorenz, Mascart, Chappius, Rayleigh, and Rivière and Prytz. When the number given rests on the authority of one observer the name of that observer is given. The values are for 0° Centigrade and 760 mm. pressure.

Substance.	Kind of light.	Indices of refraction and authority.	Substance.	Kind of light.	Indices of refraction and authority.
Acetone	D	1.001079–1.001100	Hydrogen	white	1.000138–1.000143
Ammonia	white	1.000381–1.000385	"	white	1.000139–1.000143
"	D	1.000373–1.000379	Hydrogen sul-	D	1.000644 Dulong.
Argon	D	1.000281 Rayleigh.	phide	D	1.000623 Mascart.
Benzene	D	1.001700–1.001823	Methane	white	1.000443 Dulong.
Bromine	D	1.001152 Mascart.	"	D	1.000444 Mascart.
Carbon dioxide	white	1.000449–1.000450	Methyl alcohol	D	1.000549–1.000623
" "	D	1.000448–1.000454	Methyl ether	D	1.000891 Mascart.
Carbon disul-	white	1.001500 Dulong.	Nitric oxide	white	1.000303 Dulong.
phide	D	1.001478–1.001485	" "	D	1.000297 Mascart.
Carbon mon-	white	1.000340 Dulong.	Nitrogen	white	1.000295–1.000300
oxide	white	1.000335 Mascart.	"	D	1.000296–1.000298
Chlorine	white	1.000772 Dulong.	Nitrous oxide	white	1.000503–1.000507
"	D	1.000773 Mascart.	" "	D	1.000516 Mascart.
Chloroform	D	1.001436–1.001464	Oxygen	white	1.000272–1.000280
Cyanogen	white	1.000834 Dulong.	"	D	1.000271–1.000272
"	D	1.000784–1.000825	Pentane	D	1.001711 Mascart.
Ethyl alcohol	D	1.000871–1.000885	Sulphur dioxide	white	1.000665 Dulong.
Ethyl ether	D	1.001521–1.001544	" "	D	1.000686 Ketteler.
Helium	D	1.000043 Rayleigh.	Water	white	1.000261 Jamin.
Hydrochloric	white	1.000449 Mascart.	"	D	1.000249–1.000259
acid	D	1.000447 "			

ROTATION OF PLANE OF POLARIZED LIGHT.

A few examples are here given showing the effect of wave-length on the rotation of the plane of polarization. The rotations are for a thickness of one decimetre of the solution. The examples are quoted from Landolt & Börnstein's "Phys. Chem. Tab." The following symbols are used: —

p = number grammes of the active substance in 100 grammes of the solution.
c = " " solvent " " " "
q = " " active " " cubic centimetre "

Right-handed rotation is marked +, left-handed —.

Line of spectrum.	Wave-length according to Ångström in cms. × 10^8.	Tartaric acid,* CuH_6O_6, dissolved in water. q = 50 to 95, temp. = 24° C.	Camphor,* $C_{10}H_{16}O$, dissolved in alcohol. q = 50 to 95, temp. = 22.9° C.	Santonin,† $C_{15}H_{18}O_3$, dissolved in chloroform. q = 75 to 96.5, temp. = 20° C.
B	68.67			— 140°.1 + 0.2085 q
C	65.62	+ 2°.748 + 0.09446 q	38°.549 — 0.0852 q	— 149.3 + 0.1555 q
D	58.92	+ 1.950 + 0.13030 q	51.945 — 0.0964 q	— 202.7 + 0.3086 q
E	52.69	+ 0.153 + 0.17514 q	74.331 — 0.1343 q	— 285.6 + 0.5820 q
b_1	51.83	–	–	— 302.38 + 0.6557 q
b_2	51.72	— 0.832 + 0.19147 q	79.348 — 0.1451 q	–
F	48.61	— 3.598 + 0.23977 q	99.601 — 0.1912 q	— 365.55 + 0.8284 q
e	43.83	— 9.657 + 0.31437 q	149.696 — 0.2346 q	— 534.98 + 1.5240 q

			Santonin,† $C_{15}H_{18}O_3$,			
Line of spectrum.	Wave-length.	Santonin,† $C_{15}H_{18}O_3$, * dissolved in alcohol. c = 1.782. temp. = 20° C.	dissolved in alcohol. c = 4.046. temp. = 20° C.	dissolved in chloroform c = 3.1–30.5. temp. = 20° C.	Santonic acid,† $C_{15}H_{20}O_4$, dissolved in chloroform. c = 27.192. temp. = 20° C.	Cane sugar,‡ $C_{12}H_{22}O_{11}$, dissolved in water. p = 10 to 30.
B	68.67	— 110.4°	442°	484°	— 49°	47°.56
C	65.62	— 118.8	504	549	— 57	52.70
D	58.92	— 161.0	693	754	— 74	60.41
E	52.69	— 222.6	991	1088	— 105	84.56
b_1	51.83	— 237.1	1053	1148	— 112	–
b_2	51.72	–	–	–	–	87.88
F	48.61	— 261.7	1323	1444	— 137	101.18
e	43.83	— 380.0	2011	2201	— 197	–
G	43.07	–	–	–	–	131.96
g	42.26	–	2381	2610	— 230	–

* Arndtsen, "Ann. Chim. Phys." (3) 54, 1858.
† Narini, "R. Acc. dei Lincei," (3) 13, 1882.
‡ Stefan, "Sitzb. d. Wien. Akad." 52, 1865.

ROTATION OF PLANE OF POLARIZED LIGHT.

Sodium chlorate (Guye, C. R. 108, 1889).				Quartz (Soret & Sarasin, Arch. de Gen. 1882, or C. R. 95, 1882).*					
Spectrum line.	Wave-length.	Temp. C.	Rotation per mm.	Spectrum line.	Wave-length.	Rotation per mm.	Spectrum line.	Wave-length.	Rotation per mm.
a	71.769	15°.0	2°.068	A	76.04	12°.668	Cd_9	36.090	63°.268
B	67.889	17.4	2.318	a	71.836	14.304	N	35.818	64.459
C	65.073	20.6	2.599	B	68.671	15.746	Cd_{10}	34.655	69.454
D	59.085	18.3	3.104				O	34.406	70.587
E	53.233	16.0	3.841	C	65.621	17.318			
F	48.912	11.9	4.587	D_2	58.951	21.684	Cd_{11}	34.015	72.448
G	45.532	10.1	5.331	D_1	58.891	21.727	P	33.600	74.571
G	42.834	14.5	6.005				Q	32.858	78.579
H	40.714	13.3	6.754	E	52.691	27.543	Cd_{12}	32.470	80.459
L	38.412	14.0	7.654	F	48.607	32.773			
M	37.352	10.7	8.100	G	43.072	42.604	R	31.798	84.972
N	35.544	12.9	8.861				Cd_{17}	27.467	121.052
P	33.931	12.1	9.801	h	41.012	47.481	Cd_{18}	25.713	143.266
Q	32.341	11.9	10.787	H	39.681	51.193	Cd_{23}	23.125	190.426
R	30.645	13.1	11.921	K	39.333	52.155			
T	29.918	12.8	12.424				Cd_{24}	22.645	201.824
Cd_{17}	28.270	12.2	13.426	L	38.196	55.625	Cd_{25}	21.935	220.731
Cd_{18}	25.038	11.6	14.965	M	27.262	58.894	Cd_{26}	21.431	235.972

* The paper is quoted from a paper by Ketteler in "Wied. Ann." vol. 21, p. 444. The wave-lengths are for the Fraunhofer lines, Ångström's values for the ultra violet sun, and Cornu's values for the cadmium lines.

Table 201.

LOWERING OF FREEZING-POINT BY SOLUTION OF SALTS.

Under P is the number of grammes of the substance dissolved in 100 cubic centimetres of water. Under C is the amount of lowering of the freezing-point. The data have been obtained by interpolation from the results published by the authorities quoted.

Substance and observer.	P	C°
$AgNO_3$	5	0.93
F. M. Raoult.*	10	1.71
	15	2.38
	20	2.97
	25	3.53
	30	4.00
	35	4.43
	40	4.80
	45	5.15
	50	5.45
	55	5.75
	60	6.00
	65	6.26
$Ca(NO_3)_2$	1	0.28
F. M. Raoult.*	2	0.56
	3	0.84
	4	1.12
	5	1.40
	10	2.78
	15	4.26
	20	6.00
$Cd(NO_3)_2$	0.5	0.112
Harry C. Jones.§	1.0	0.217
Na_2SO_4	1	0.28
F. M. Raoult.*	2	0.56
	3	0.84
	4	1.12
	5	1.40
K_2SO_4	0.5	0.14
S. Arrhenius.	1.0	0.27
	1.5	0.39
	2.0	0.51
	2.5	0.63
	3.0	0.74
	3.5	0.85
	4.0	0.96
	4.5	1.07
	5.0	1.17
	5.5	1.27
	6.0	1.37
	6.5	1.47
	7.0	1.57
	7.5	1.67
	8.0	1.77
$MgSO_4$	1	0.18
F. M. Raoult.*	2	0.35
	3	0.52
	4	0.70
	5	0.89
	10	1.77
	15	2.78
	20	3.68

Substance and observer.	P	C°
$ZnSO_4$	1	0.10
F. M. Raoult.*	2	0.23
	3	0.36
	4	0.49
	5	0.61
	10	1.23
	15	1.85
	20	2.50
	25	3.19
	30	3.94
$CuSO_4$	1	0.15
F. M. Raoult.*	2	0.29
	3	0.40
	4	0.51
	5	0.62
	6	0.72
	7	0.82
	8	0.92
	9	1.02
	10	1.12
$CdSO_4$	1	0.09
F. M. Raoult.*	2	0.19
	3	0.28
	4	0.38
	5	0.48
	10	1.00
	15	1.54
	20	2.11
	25	2.77
	30	3.51
	35	4.40
NaCl	0.5	0.32
S. Arrhenius.†	1.0	0.62
	1.5	0.92
	2.0	1.22
	2.5	1.52
	3.0	1.82
KCl	0.5	0.234
Harry C. Jones.‡	1.0	0.464
	1.5	0.693
	2.0	0.915
	2.5	1.136
	3.0	1.359
LiCl	0.5	0.45
S. Arrhenius.†	1.0	0.89
	1.5	1.34
	2.0	1.78
	2.5	2.23
NH_4Cl	0.5	0.326
Harry C. Jones.‡	1.0	0.644
	1.5	0.957

Substance and observer.	P	C°
$MgCl_2$	0.5	0.26
S. Arrhenius.†	1.0	0.53
	1.5	0.81
	2.0	1.10
	2.5	1.39
	3.0	1.69
	3.5	2.00
	4.0	2.32
	4.5	2.65
	5.0	2.98
	5.5	3.32
	6.0	3.67
$BaCl_2$	0.5	0.119
Harry C. Jones.§	1.0	0.234
	1.5	0.344
	2.0	0.450
$SrCl_2$	0.5	0.17
S. Arrhenius.†	1.0	0.34
	1.5	0.50
	2.0	0.65
	2.5	0.80
	3.0	0.95
	3.5	1.12
	4.0	1.29
	4.5	1.44
	5.0	1.60
	5.5	1.76
	6.0	1.93
$CuCl_2 + 2H_2O$	0.5	0.15
S. Arrhenius.†	1.0	0.30
	1.5	0.44
	2.0	0.58
	2.5	0.72
	3.0	0.86
	3.5	1.00
	4.0	1.14
	4.5	1.29
	5.0	1.43
	5.5	1.57
	6.0	1.71
	6.5	1.85
	2.0	2.00
$CdCl_2$	0.5	0.120
Harry C. Jones.§	1.0	0.227
	1.5	0.322
$CaCl_2$	0.5	0.23
S. Arrhenius.†	1.0	0.45
	1.5	0.68
	2.0	0.91
	2.5	1.14
	3.0	1.37
	3.5	1.61
	4.0	1.85

* In "Zeits. für Physik. Chem." vol. 2, p. 489, 1888.
† Ibid. vol. 2, p. 491, 1888.
‡ Ibid. vol. 11, p. 110, 1893.
§ Ibid. vol. 11, p. 529, 1893.

LOWERING OF FREEZING-POINT BY SOLUTION OF SALTS.

Substance and observer.	P	C°
$ZnCl_2$	0.5	0.185
Harry C. Jones.*	1.0	0.348
$CdBr_2$	0.5	0.080
Harry C. Jones.*	1.0	0.142
	1.5	0.195
	2.0	0.248
	2.5	0.300
	3.0	0.352
CdI_2	1	0.06
S. Arrhenius.†	2	0.12
	3	0.19
	4	0.25
	5	0.32
	10	0.63
	15	0.92
	20	1.22
	25	1.52
NaOH	0.1	0.092
Harry C. Jones.‡	0.2	0.178
	0.3	0.260
	0.4	0.337
	0.5	0.410
KOH	0.1	0.064
Harry C. Jones.‡	0.2	0.126
	0.3	0.189
	0.4	0.252
	0.5	0.312
	0.6	0.370
	0.7	0.430
NH_4OH	0.05	0.028
Harry C. Jones.‡	0.10	0.056
	0.15	0.084
	0.20	0.113
	0.25	0.143
Na_2CO_3	0.1	0.048
Harry C. Jones.‡	0.2	0.096
	0.3	0.143
	0.4	0.188
	0.5	0.228
	1.0	0.417
K_2CO_3	0.1	0.039
Harry C. Jones.‡	0.2	0.078
	0.3	0.116
	0.4	0.152
	0.5	0.187
	1.0	0.343

Substance and observer.	P	C°
Alcohol, C_2H_6O	0.1	0.044
Harry C. Jones.‡	0.2	0.087
	0.3	0.129
	0.4	0.170
	0.5	0.212
	1.0	0.402
Acetic acid,	0.1	0.034
$C_2H_4O_2$	0.2	0.067
Harry C. Jones.‡	0.3	0.099
	0.4	0.131
	0.5	0.162
	1.0	0.313
$P(OH)_3$	0.5	0.18
S. Arrhenius.†	1.0	0.35
	1.5	0.50
	2.0	0.65
HIO_3	0.5	0.09
S. Arrhenius.†	1.0	0.18
	1.5	0.27
	2.0	0.35
	2.5	0.44
	3.0	0.52
	3.5	0.61
	4.0	0.69
	4.5	0.78
	5.0	0.86
HCl	0.1	0.099
Harry C. Jones.‡	0.2	0.198
	0.3	0.296
	0.4	0.395
	0.5	0.493
HNO_3	0.1	0.061
Harry C. Jones.‡	0.2	0.118
	0.3	0.175
	0.4	0.232
	0.5	0.285
	0.6	0.338
	0.7	0.390

Substance and observer.	P	C°
H_2SO_3	0.5	0.15
S. Arrhenius.†	1.0	0.30
	1.5	0.45
	2.0	0.60
	2.5	0.75
	3.0	0.90
	3.5	1.05
	4.0	1.20
	4.5	1.35
	5.0	1.50
	5.5	1.65
	6.0	1.80
	6.5	1.95
	7.0	2.10
H_2SO_4	0.1	0.044
Harry C. Jones.‡	0.2	0.088
	0.3	0.131
	0.4	0.172
	0.5	0.212
	1.0	0.402
H_3PO_4	0.5	0.14
S. Arrhenius.†	1.0	0.27
	1.5	0.38
	2.0	0.49
	2.5	0.60
	3.0	0.70
	3.5	0.80
	4.0	0.90
Cane sugar.	0.5	0.030
F. M. Raoult.§	1.0	0.060
	2.0	0.118
	3.0	0.176
	4.0	0.234
	5.0	0.292
	10.0	0.587
	15.0	0.881
	20.0	1.174
	25.0	1.465
	30.0	1.752
	35.0	2.048
	40.0	2.333
Glycerine.‖	1.0	0.22
S. Arrhenius.†	2.0	0.42
	3.0	0.64
	4.0	0.87
	5.0	1.11
	6.0	1.34
	8.0	1.83
	10.0	2.32
	12.0	2.83

* In "Zeits. für Physik. Chem." vol. 11, p. 529, 1883.
† Ibid. vol. 2, p. 491, 1888.
‡ Ibid. vol. 12, p. 623, 1893.
§ F. M. Raoult, C. R. 114, p. 268.
‖ 50 % solution solidifies at —31° C., according to Fabian, "Ding. Poly. Journ." vol. 155, p. 345. This gives an average of .3 per gramme.

TABLE 202.

VAPOR PRESSURE OF SOLUTIONS OF SALTS IN WATER.*

The first column gives the chemical formula of the salt. The headings of the other columns give the number of gramme-molecules of the salt in a litre of water. The numbers in these columns give the lowering of the vapor pressure produced by the salt at the temperature of boiling water under 76 centimetres barometric pressure.

Substance.	0.5	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0
$Al_2(SO_4)_3$	12.8	36.5							
$AlCl_3$	22.5	61.0	179.0	318.0					
$Ba(SO_3)_2$	6.6	15.4	34.4						
$Ba(OH)_2$	12.3	22.5	39.0						
$Ba(NO_3)_2$	13.5	27.0							
$Ba(ClO_3)_2$	15.8	33.3	70.5	108.2					
$BaCl_2$	16.4	36.7	77.6						
$BaBr_2$	16.8	38.8	91.4	150.0	204.7				
$Ca(SO_3)_2$	9.9	23.0	56.0	106.0					
$Ca(NO_3)_2$	16.4	34.8	74.6	139.3	161.7	205.4			
$CaCl_2$	17.0	39.8	95.3	166.6	241.5	319.5			
$CaBr_2$	17.7	44.2	105.8	191.0	283.3	368.5			
$CdSO_4$	4.1	8.9	18.1						
CdI_2	7.6	14.8	33.5	52.7					
$CdBr_2$	8.6	17.8	36.7	55.7	80.0				
$CdCl_2$	9.6	18.8	36.7	57.0	77.3	99.0			
$Cd(NO_3)_2$	15.9	36.1	78.0	122.2					
$Cd(ClO_3)_2$	17.5								
$CoSO_4$	5.5	10.7	22.9	45.5					
$CoCl_2$	15.0	34.8	83.0	136.0	186.4				
$Co(NO_3)_2$	17.3	39.2	89.0	152.0	218.7	282.0	332.0		
$FeSO_4$	5.8	10.7	24.0	42.4					
H_3BO_3	6.0	12.3	25.1	38.0	51.0				
H_3PO_4	6.6	14.0	28.6	45.2	62.0	81.5	103.0	146.9	189.5
H_3AsO_4	7.3	15.0	30.2	46.4	64.9				
H_2SO_4	12.9	26.5	62.8	104.0	148.0	198.4	247.0	343.2	
KH_2PO_4	10.2	19.5	33.3	47.8	60.5	73.1	85.2		
KNO_3	10.3	21.1	40.1	57.6	74.5	88.2	102.1	126.3	148.0
$KClO_3$	10.6	21.6	42.8	62.1	80.0				
$KBrO_3$	10.9	22.4	45.0						
$KHSO_4$	10.9	21.9	43.3	65.3	85.5	107.8	129.2	170.0	
KNO_3	11.1	22.8	44.8	67.0	90.0	110.5	130.7	167.0	198.8
$KClO_4$	11.5	22.3							
KCl	12.2	24.4	48.8	74.1	100.9	128.5	152.2		
$KHCO_3$	11.6	23.6	59.0	77.6	104.2	132.0	160.0	210.0	255.0
KI	12.5	25.3	52.2	82.6	112.2	141.5	171.8	225.5	278.5
$K_2C_2O_4$	13.9	28.3	59.8	94.2	131.0				
K_2WO_4	13.9	33.0	75.0	123.8	175.4	226.4			
K_2CO_3	14.4	31.0	68.3	105.5	152.0	209.0	258.5	350.0	
KOH	15.0	29.5	64.0	99.2	140.0	181.8	223.0	309.5	387.8
K_2CrO_4	16.2	29.5	60.0						
$LiNO_3$	12.2	25.9	55.7	88.9	122.2	155.1	188.0	253.4	309.2
$LiCl$	12.1	25.5	57.1	95.0	132.5	175.5	219.5	311.5	393.5
$LiBr$	12.2	26.2	60.0	97.0	140.0	186.3	241.5	341.5	438.0
Li_2SO_4	13.3	28.1	56.8	89.0					
$LiHSO_4$	12.8	27.0	57.0	93.0	130.0	168.0			
LiI	13.6	28.6	64.7	105.2	154.5	206.0	264.0	357.0	445.0
Li_2SiFl_6	15.4	34.0	70.0	106.0					
$LiOH$	15.9	37.4	78.1						
Li_2CrO_4	16.4	32.6	74.0	120.0	171.0				

* Compiled from a table by Tammann, "Mém. Ac. St. Petersb." 35, No. 9, 1887. See also Referate, "Zeit. f. Phys." ch. 2, 42, 1886.

VAPOR PRESSURE OF SOLUTIONS OF SALTS IN WATER.

Substance.	0.5	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0
$MgSO_4$	6.5	12.0	24.5	47.5					
$MgCl_2$	16.8	39.0	100.5	183.3	277.0	377.0			
$Mg(NO_3)_2$	17.6	42.0	101.0	174.8					
$MgBr_2$	17.9	44.0	115.8	205.3	298.5				
$MgH_2(SO_4)_2$	18.3	46.0	116.0						
$MnSO_4$	6.0	10.5	21.0						
$MnCl_2$	15.0	34.0	76.0	122.3	167.0	209.0			
NaH_2PO_4	10.5	20.0	36.5	51.7	66.8	82.0	96.5	126.7	157.1
$NaHSO_4$	10.9	22.1	47.3	75.0	100.2	126.1	148.5	189.7	231.4
$NaNO_2$	10.6	22.5	46.2	68.1	90.3	111.5	131.7	167.8	198.8
$NaClO_3$	10.5	23.0	48.4	73.5	98.5	123.3	147.5	196.5	223.5
$(NaPO_3)_6$	11.6								
$NaOH$	11.8	22.8	48.2	77.3	107.5	139.1	172.5	243.3	314.0
$NaNO_3$	11.6	24.4	50.0	75.0	98.2	122.5	146.5	189.0	226.2
$NaHPO_4$	12.1	23.5	43.0	60.0	78.7	99.8	122.1		
$NaHCO_3$	12.9	24.1	48.2	77.6	102.2	127.8	152.0	198.0	239.4
$NaSO_4$	12.6	25.0	48.9	74.2					
$NaCl$	12.3	25.2	52.1	80.0	111.0	143.0	176.5		
$NaBrO_3$	12.1	25.0	54.1	81.3	108.8	136.0			
$NaBr$	12.6	25.9	57.0	89.2	124.2	159.5	197.5	268.0	
NaI	12.1	25.6	60.2	99.5	136.7	177.5	221.0	301.5	370.0
$Na_4P_2O_7$	13.2	22.0							
Na_2CO_3	14.3	27.3	53.5	80.2	111.0				
$Na_2C_2O_4$	14.5	30.0	65.8	105.8	146.0				
Na_2WO_4	14.8	33.6	71.6	115.7	162.6				
Na_3PO_4	16.5	30.0	52.5						
$(NaPO_3)_3$	17.1	36.5							
NH_4NO_3	12.8	22.0	42.1	62.7	82.9	103.8	121.0	152.2	180.0
$(NH_4)_2SiFl_6$	11.5	25.0	44.5						
NH_4Cl	12.0	23.7	45.1	69.3	94.2	118.5	138.2	179.0	213.8
NH_4HSO_4	11.5	22.0	46.8	71.0	94.5	118.	139.0	181.2	218.0
$(NH_4)_2SO_4$	11.0	24.0	46.5	69.5	93.0	117.0	141.8		
NH_4Br	11.9	23.9	48.8	74.1	99.4	121.5	145.5	190.2	228.5
NH_4I	12.9	25.1	49.8	78.5	104.5	132.3	156.0	200.0	243.5
$NiSO_4$	5.0	10.2	21.5						
$NiCl_2$	16.1	37.0	86.7	147.0	212.8				
$Ni(NO_3)_2$	16.1	37.3	91.3	156.2	235.0				
$Pb(NO_3)_2$	12.3	23.5	45.0	63.0					
$Sr(SO_3)_2$	7.2	20.3	47.0						
$Sr(NO_3)_2$	15.8	31.0	64.0	97.4	131.4				
$SrCl_2$	16.8	38.8	91.4	156.8	223.3	281.5			
$SrBr_2$	17.8	42.0	101.1	179.0	267.0				
$ZnSO_4$	4.9	10.4	21.5	42.1	66.2				
$ZnCl_2$	9.2	18.7	46.2	75.0	107.0	153.0	195.0		
$Zn(NO_3)_2$	16.6	39.0	93.5	157.5	223.8				

TABLE 203.

RISE OF BOILING-POINT PRODUCED BY SALTS DISSOLVED IN WATER.*

This table gives the number of grammes of the salt which, when dissolved in 100 grammes of water, will raise the boiling-point by the amount stated in the headings of the different columns. The pressure is supposed to be 76 centimetres.

Salt.	1° C.	2°	3°	4°	5°	7°	10°	15°	20°	25°
$BaCl_2 + 2H_2O$	15.0	31.1	47.3	63.5	(71.6 gives 4°.5 rise of temp.)					
$CaCl_2$	6.0	11.5	16.5	21.0	25.0	32.0	41.5	55.5	69.0	84.5
$Ca(NO_3)_2 + 2H_2O$	12.0	25.5	39.5	53.5	68.5	98.7	152.5	240.0	331.5	443.5
KOH	4.7	9.3	13.6	17.4	20.5	26.4	34.5	47.0	57.5	67.3
$KC_2H_3O_2$	6.0	12.0	18.0	24.5	31.0	44.0	63.5	98.0	134.0	171.5
KCl	9.2	16.7	23.4	29.9	36.2	48.4	(57.4 gives a rise of 8°.5)			
K_2CO_3	11.5	22.5	32.0	40.0	47.5	60.5	78.5	103.5	127.5	152.5
$KClO_3$	13.2	27.8	44.6	62.2						
KI	15.0	30.0	45.0	60.0	74.0	99.5	134.	185.0	(220 gives 18°.5)	
KNO_3	15.2	31.0	47.5	64.5	82.0	120.5	188.5	338.5		
$K_2C_4H_4O_6 + \frac{1}{2}H_2O$	18.0	36.0	54.0	72.0	90.0	126.5	182.0	284.0		
$KNaC_4H_4O_6$	17.3	34.5	51.3	68.1	84.8	119.0	171.0	272.5	390.0	510.0
$KNaC_4H_4O_6 + 4H_2O$	25.0	53.5	84.0	118.0	157.0	266.0	554.0	5510.0		
$LiCl$	3.5	7.0	10.0	12.5	15.0	18.5	26.0	35.0	42.5	50.0
$LiCl + 2H_2O$	6.5	13.0	19.5	26.0	32.0	44.0	62.0	92.0	123.0	160.5
$MgCl_2 + 6H_2O$	11.0	22.0	33.0	44.0	55.0	77.0	110.0	170.0	241.0	334.5
$MgSO_4 + 7H_2O$	41.5	87.5	138.0	196.0	262.0					
$NaOH$	4.3	8.0	11.3	14.3	17.0	22.4	30.0	41.0	51.0	60.1
$NaCl$	6.6	12.4	17.2	21.5	25.5	33.5	(40.7 gives 8°.8 rise)			
$NaNO_3$	9.0	18.5	28.0	38.0	48.0	68.0	99.5	156.0	222.0	
$NaC_2H_3O_2 + 3H_2O$	14.9	30.0	46.1	62.5	79.7	118.1	194.0	484.0	6250.0	
$Na_2S_2O_3$	14.0	27.0	39.0	49.5	59.0	76.0	104.0	147.0	214.5	302.0
Na_2HPO_4	17.2	34.4	51.4	68.4	85.3					
$Na_2C_4H_4O_6 + 2H_2O$	21.4	44.4	68.2	93.9	121.3	183.0	(237.3 gives 8°.4 rise)			
$Na_2S_2O_3 + 5H_2O$	23.8	50.0	78.6	108.1	139.3	216.0	400.0	1765.0		
$Na_2CO_3 + 10H_2O$	34.1	86.7	177.6	369.4	1052.9					
$Na_2B_4O_7 + 10H_2O$	39.	93.2	254.2	898.5	(5555.5 gives 4°.5 rise)					
NH_4Cl	6.5	12.8	19.0	24.7	29.7	39.6	56.2	88.5		
NH_4NO_3	10.0	20.0	30.0	41.0	52.0	74.0	108.0	172.0	248.0	337.0
NH_4SO_4	15.4	30.1	44.2	58.0	71.8	99.1	(115.3 gives 108.2)			
$SrCl_2 + 6H_2O$	20.0	40.0	60.0	81.0	103.0	150.0	234.0	524.0		
$Sr(NO_3)_2$	24.0	45.0	63.6	81.4	97.6					
$C_4H_6O_6$	17.0	34.4	52.0	70.0	87.0	123.0	177.0	273.0	374.0	484.0
$C_2H_2O_4 + 2H_2O$	19.0	40.0	62.0	86.0	112.0	169.0	262.0	536.0	1316.0	50000.0
$C_6H_8O_7 + H_2O$	29.0	58.0	87.0	116.0	145.0	208.0	320.0	553.0	952.0	

Salt.	40°	60°	80°	100°	120°	140°	160°	180°	200°	240°
$CaCl_2$	137.5	222.0	314.0							
KOH	92.5	121.7	152.6	185.0	219.8	263.1	312.5	375.0	444.4	623.0
$NaOH$	93.5	150.8	230.0	345.0	526.3	800.0	1333.0	2353.0	6452.0	–
NH_4NO_3	682.0	1370.0	2400.0	4099.0	8547.0	∞				
$C_4H_6O_6$	980.0	3774.0	(infinity gives 170)							

* Compiled from a paper by Gerlach, "Zeit. f. Anal. Chem." vol. 26.

CONDUCTIVITY FOR HEAT.

Metals and Alloys.

The coefficient k is the quantity of heat in therms which is transmitted per second through a plate one centimetre thick per square centimetre of its surface when the difference of temperature between the two faces of the plate is one degree Centigrade. The coefficient k is found to vary with the absolute temperature of the plate, and is expressed approximately by the equation $k_t = k_0 (1 + at)$. In the table k_0 is the value of k_t for 0° C., t the temperature Centigrade, and a a constant.

Substance.	t	k_t	a	Authority.
Aluminium	0	0.3435	.0005356	1
	100	.3619		
Antimony	0	.0442	—.001041	1
	100	.0396		
Bismuth	0	.0177	—.000735	1
	100	.0164		
Brass (yellow)	0	.2041	.002445	1
	100	.2540		
" (red)	0	.2460	.001492	1
	100	.2827		
Cadmium	0	.2200	—.000705	1
	100	.2045		
Copper	0	1.0405	.000039	2
	0	.7189	.000051	1
	100	.7226		
German silver	0	.0700	.002670	1
	100	.0887		
Iron	0	.1665	—.000228	1
	100	.1627		
" (wrought)*	0	.2070	–	3
	100	.1567		
Lead	0	.0836	—.000861	1
	100	.0764		
Mercury	0	.0148	–	4
	50	.0189		
	0–100	.0201	.001267	2
Magnesium	0–100	.3760	.000000	1
Steel (hard)	–	.0620	–	5
" (soft)	–	.1110	–	5
Silver	0	1.0960	–	4
Tin	0	.1528	—.000687	1
	100	.1423		
Wood's alloy	–	.0319	–	4
Zinc	0	.3030	–	2

Substance.	t	k_t	Authority.
Clay slate, (Devonshire)	–	.00272	6
Granite from	–	.00510	6
to	–	.00550	
Slate: along cleavage from	–	.00550	6
to	–	.00650	
across cleavage from	–	.00315	6
to	–	.00360	
Marbles, including limestone, calcite, and compact dolomite from	–	.00470	6
to	–	.00560	
Micaceous flagstone: along cleavage	–	.00632	6
across cleavage	–	.00441	6
Sand (white dry)	–	.00093	6
Sandstone and hard grit (dry) from	–	.00545	6
to	–	.00565	
Serpentine (Cornwall red)	–	.00441	6
Snow in compact layers	–	.00051	7
Plaster of Paris	–	.0013	6
Pasteboard	–	.00045	8
Strawboard	–	.00033	8
Paraffin	–	.00014	8
	0	.00023	9
	100	.00168	9
Sawdust	–	.00012	8
Vulcanite	–	.00087	10
Vulcanized rubber (soft) from	–	.00034	6
to	–	.00054	6
Wood, Fir: parallel to axis	–	.0003	8
perpendicular to axis	–	.00009	8
Wax (bees)	–	.00009	8

AUTHORITIES.

1 Lorenz.	3 J. Forbes.	5 Kohlrausch.	7 Hjeltström.	9 R. Weber.
2 Berget.	4 H. F. Weber.	6 H. L. & D.†	8 G. Forbes.	10 Stefan.

* A repetition of Forbes's experiments by Mitchell, under the direction of Tait, shows the conductivity to increase with rise of temperature. (Trans. R. S. E. vol. 33, 1887.)

† Herschel, Lebour, and Dunn (British Association Committee).

CONDUCTIVITY FOR HEAT.

TABLE 205. — Various Substances.

Substance.	t	k_t	Authority.
Carbon	0	.000405	1
Cement	0	.000162	1
Cork	0	.000717	1
Cotton wool	0	.000043	1
Cotton pressed	–	.000033	1
Chalk	–	.002000	2
Ebonite	49	.000370	2
Felt	0	.000087	1
Flannel	0	.000035	1
Glass from	–	.0005	3
Glass to	–	.0023	3
Horn	–	.000087	1
Haircloth	–	.000042	1
Ice	–	.00223	1
Ice	–	.00568	4
Caen stone (building limestone)	–	.00433	2
Calcareous sandstone (freestone)	–	.00211	2

AUTHORITIES.

1 G. Forbes. 2 H., L., & D.* 3 Various. 4 Neumann.

TABLE 206. — Water and Salt Solutions.

Substance.	Density.	t	k_t	Authority.
Water	–	–	.002	1
"	–	0	.00120	2
"	–	9–15	.00136	2
"	–	4	.00129	3
"	–	30	.00157	4
"	–	18	.00124	5
Solutions in water.				
$CuSO_4$	1.160	4.4	.00118	2
KCl	1.026	13	.00116	4
$NaCl$	33⅓%	10–18	.00267	6
H_2SO_4	1.054	20.5	.00126	5
"	1.100	20.5	.00128	5
"	1.180	21	.00130	5
$ZnSO_4$	1.134	4.5	.00118	2
"	1.136	4.5	.00115	2

AUTHORITIES.

1 Bottomley. 2 H. F. Weber. 3 Wachsmuth. 4 Graetz. 5 Chree. 6 Winkelmann.

TABLE 207. — Organic Liquids.

Substance.	t	$k_t \times 1000$	a	Authority.
Acetic acid	9–15	.472	–	1
Alcohols: amyl	9–15	.328	–	1
ethyl	9–15	.423	–	1
methyl	9–15	.495	–	1
Carbon disulphide	9–15	.343	–	1
Chloroform	9–15	.288	–	1
Ether	9–15	.303	–	1
Glycerine	9–15	.637	0.12	2
Oils: olive	–	.395	–	3
castor	–	.425	–	3
petroleum	13	.355	.011	2
turpentine	13	.325	.0067	2

AUTHORITIES.

1 H. F. Weber. 2 Graetz. 3 Wachsmuth.

TABLE 208. — Gases.

Substance.	t	$k_t \times 1000$	a	Authority.
Air	0	.568	.00190	1
Ammonia	0	.458	.00548	1
Carbon monoxide	0	.499	–	1
" dioxide	0	.307	–	1
Ethylene	0	.395	.00445	1
Hydrogen	0	.327	.00175	1
Methane	7–8	.647	–	1
Nitrogen	7–8	.524	–	1
Nitrous oxide	7–8	.350	.00446	1
Oxygen	7–8	.563	–	1

AUTHORITY.

1 Winkelmann.

* Herschel, Lebour, and Dunn (British Association Committee).

FREEZING MIXTURES.*

Column 1 gives the name of the principal refrigerating substance, *A* the proportion of that substance, *B* the proportion of a second substance named in the column, *C* the proportion of a third substance, *D* the temperature of the substances before mixture, *E* the temperature of the mixture, *F* the lowering of temperature, *G* the temperature when all snow is melted, when snow is used, and *H* the amount of heat absorbed in heat units (therms when *A* is grammes). Temperatures are in Centigrade degrees.

Substance.	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*
$NaC_2H_3O_2$ (cryst.)	85	H_2O–100	–	10.7	–4.7	15.4	–	–
NH_4Cl	30	" "	–	13.3	–5.1	18.4	–	–
$NaNO_3$	75	" "	–	13.2	–5.3	18.5	–	–
$Na_2S_2O_3$ (cryst.)	110	" "	–	10.7	–8.0	18.7	–	–
KI	140	" "	–	10.8	–11.7	22.5	–	–
$CaCl_2$ (cryst.)	250	" "	–	10.8	–12.4	23.2	–	–
NH_4NO_3	60	" "	–	13.6	–13.6	27.2	–	–
$(NH_4)_2SO_4$	25	" 50	NH_4NO_3–25	–	–	26.0	–	–
NH_4Cl	25	" "	" "	–	–	22.0	–	–
$CaCl_2$	25	" "	" "	–	–	20.0	–	–
KNO_3	25	" "	NH_4Cl–25	–	–	20.0	–	–
Na_2SO_4	25	" "	" "	–	–	19.0	–	–
$NaNO_3$	25	" "	" "	–	–	17.0	–	–
K_2SO_4	10	Snow 100	–	–1	–1.9	0.9	–	
Na_2CO_3 (cryst.)	20	" "	–	–1	–2.0	1.0	–	–
KNO_3	13	" "	–	–1	–2.85	1.85	–	–
$CaCl_2$	30	" "	–	–1	–10.9	9.9	–	–
NH_4Cl	25	" "	–	–1	–15.4	14.4	–	–
NH_4NO_3	45	" "	–	–1	–16.75	15.75	–	–
$NaNO_3$	50	" "	–	–1	–17.75	16.75	–	–
NaCl	33	" "	–	–1	–21.3	20.3	–	–
$H_2SO_4 + H_2O$ (66.1 % H_2SO_4)	1	" 1.097	–	–1	–37.0	36.0	–37.0	0.0
	1	" 1.26	–	–1	–36.0	35.0	–30.2	17.0
	1	" 1.38	–	–1	–35.0	34.0	–25.0	27.0
	1	" 2.52	–	–1	–30.0	29.0	–12.4	133.0
	1	" 4.32	–	–1	–25.0	24.0	–7.0	273.0
	1	" 7.92	–	–1	–20.0	19.0	–3.1	553.0
	1	" 13.08	–	–1	–16.0	15.0	–2.1	967.0
$CaCl_2 + 6H_2O$	1	" 0.35	–	0	–	–	0.0	52.1
	1	" .49	–	0	–	–	–19.7	49.5
	1	" .61	–	0	–	–	–39.0	40.3
	1	" .70	–	0	–	–	–54.9†	30.0
	1	" .81	–	0	–	–	–40.3	46.8
	1	" 1.23	–	0	–	–	–21.5	88.5
	1	" 2.46	–	0	–	–	–9.0	192.3
	1	" 4.92	–	0	–	–	–4.0	392.3
Alcohol at 4°	77	" 73	–	0	–30.0	–	–	–
	–	CO_2 solid	–	–	–72.0	–	–	–
Chloroform	–	" "	–	–	–77.0	–	–	–
Ether	–	" "	–	–	–77.0	–	–	–
Liquid SO_2	–	" "	–	–	–82.0	–	–	–
NH_4NO_3	1	H_2O–.75	–	20	5.0	–	–	33.0
	1	" .94	–	20	–4.0	–	–	21.0
	1	" "	–	10	–4.0	–	–	34.0
	1	" "	–	5	–4.0	–	–	40.5
	1	Snow "	–	0	–4.0	–	–	122.2
	1	H_2O–1.20	–	10	–14.0	–	–	17.9
	1	Snow "	–	0	–14.0	–	–	129.5
	1	H_2O–1.31	–	10	–17.5†	–	–	10.6
	1	Snow "	–	0	–17.5†	–	–	131.9
	1	H_2O–3.61	–	10	–8.0	–	–	0.4
	1	Snow "	–	0	–8.0	–	–	327.0

* Compiled from the results of Cailletet and Colardeau, Hammerl, Hanamann, Moritz, Pfanndler, Rudorf, and Tollinger.

† Lowest temperature obtained.

CRITICAL TEMPERATURES, PRESSURES, VOLUMES, AND DENSITIES OF GASES.*

θ = Critical temperature.
P = Pressure in atmospheres.
ϕ = Volume referred to air at 0° and 76 centimetres pressure.
d = Density in grammes per cubic centimetre.

Substance.	θ	P	ϕ	d	Observer.
Air	—140.0	39.0	-	-	Olszewski.
Alcohol (C_2H_6O) . . .	243.6	62.76	0.00713	0.288	Ramsay and Young.
" " . . .	233.7	-	-	-	Jouk (lowest value recorded).
" (CH_4O) . . .	239.95	78.5	-	-	Ramsay and Young.
Ammonia	130.0	115.0	-	-	Dewar.
Argon	—121.0	50.6	-	1.5	Olszewski.
Benzene	288.5	47.9	0.00981	0.355	Young.
Carbon dioxide	30.92	77	0.0066	-	Andrews.
" monoxide . . .	—141.1	35.9	-	-	Wroblewski.
" disulphide . . .	277.7	78.1	-	-	Dewar.
Chloroform	260.0	54.9	-	-	Sajotschewski.
Chlorine	141.0	83.9	-	-	Dewar.
"	148.0	-	-	-	Ladenburg.
Ether	19.7	35.77	0.01584	0.208	Battelli.
"	194.4	35.61	0.01344	0.246	Ramsay and Young.
Ethylene	9.2	58.0	-	-	Van der Waals.
"	13.0	-	0.00569	0.21	Cailletet.
Hydrogen	—220.0	20.0	-	-	Olszewski.
" chloride . . .	51.25	86.0	-	-	Ansdell.
" " . . .	52.3	86.0	-	0.61	Dewar.
" sulphide . . .	100.0	88.7	-	-	Olszewski.
Methane	—81.8	54.9	-	-	"
"	—99.5	50.0	-	-	Dewar.
Nitric oxide (NO) . . .	—93.5	71.2	-	-	Olszewski.
Nitrogen	—146.0	35.0	-	0.44	"
"	—146.0	33.0	-	-	Wroblewski.
" monoxide (N_2O) .	354.0	75.0	-	-	Dewar.
Oxygen	—118.0	50.0	-	0.6044	Wroblewski.
Sulphur dioxide . . .	155.4	78.9	-	-	Sajotschewski.
" " . . .	157.0	-	-	-	Clark.
Water	358.1	-	0.001874	0.429	Nadejdine.
"	370.0	195.5	-	-	Dewar.

* Abridged for the most part from Landolt and Boernstein's "Phys. Chem. Tab."

NOTE. — Guldberg shows (Zeit. für Phys. Chem. vol. 5, p. 375) that for a large number of organic substances the ratio of the absolute boiling to the absolute critical temperature, although not constant, lies between 0.58 and 0.7, the majority being between .65 and .7. Methane, ethane, and ammonia gave approximately 0.58. H_2S gave .566, and CS_2, N_2O, and O gave about .59.

HEAT OF COMBUSTION.

Heat of combustion of some common organic compounds.
Products of combustion, CO_2 or SO_2 and water, which is assumed to be in a state of vapor.

Substance.	Therms per gramme of substance.	Authority.
Acetylene	11923	Thomsen.
Alcohols: Amyl	8958	Favre and Silbermann.
Ethyl	7183	" " "
Methyl	5307	" " "
Benzene	9977	Stohmann, Kleber, and Langbein.
Coals: Bituminous	7400–8500	Various.
Anthracite	7800	Average of various.
Lignite	6900	" " "
Coke	7000	" " "
Carbon disulphide	3244	Berthelot.
Dynamite, 75 %	1290	Roux and Sarran.
Gas: Coal gas	5800–11000	Mahler.
Illuminating	5200–5500	Various.
Methane	13063	Favre and Silbermann.
Naphthalene	9618–9793	Various.
Gunpowder	720–750	"
Oils: Lard	9200–9400	"
Olive	9328–9442	Stohmann.
Petroleum, Am. crude	11094	Mahler.
" " refined	11045	"
" Russian	10800	"
Woods: Beech with 12.9 % H_2O	4168	Gottlieb.
Birch " 11.83 "	4207	"
Oak " 13.3 "	3990	"
Pine " 12.17 "	4422	"

Heat of combination of elements and compounds expressed in units, such that when unit mass of the substance is units, which will be raised in temperature

Substance.	Combined with oxygen forms —	Heat units.	Combined with chlorine forms —	Heat units.	Combined with sulphur forms —	Heat units.	Authority.
Calcium	CaO	3284	$CaCl_2$	4255	CaS	2300	1
Carbon — Diamond	CO_2	7859	–	–	–	–	2
" "	CO	2141	–	–	–	–	3
" — Graphite	CO_2	7796	–	–	–	–	3
Chlorine	Cl_2O	— 254	–	–	–	–	1
Copper	Cu_2O	321	$CuCl$	520	–	–	1
"	CuO	585	$CuCl_2$	819	CuS	158	1
"	"	593	–	–	–	–	4
Hydrogen*	H_2O	34154	HCl	22000	H_2S	2250	3
"	"	34800	–	–	–	–	5
"	"	34417	–	–	–	–	6
Iron	FeO	1353	$FeCl_2$	1464	$FeSH_2O$	428	3
"	–	–	$FeCl_3$	1714	–	–	3
Iodine	I_2O_5	177	–	–	–	–	1
Lead	PbO	243	$PbCl_2$	400	PbS	98	1
Magnesium	MgO	6077	$MgCl_2$	6291	MgS	3191	1
Manganese	$MnOH_2O$	1721	$MnCl_2$	2042	$MnSH_2O_2$	841	1
Mercury	Hg_2O	105	$HgCl$	206	–	–	1
"	HgO	153	$HgCl_2$	310	HgS	84	1
Nitrogen*	N_2O	— 654	–	–	–	–	1
"	NO	—1541	–	–	–	–	1
"	NO_2	— 143	–	–	–	–	1
Phosphorus (red)	P_2O_5	5272	–	–	–	–	1
" (yellow)	"	5747	–	–	–	–	7
" "	"	5964	–	–	–	–	1
Potassium	K_2O	1745	KCl	2705	K_2S	1312	8
Silver	Ag_2O	27	$AgCl$	271	Ag_2S	24	1
Sodium	Na_2O	3293	$NaCl$	4243	Na_2S	1900	8
Sulphur	SO_2	2241	–	–	–	–	1
"	"	2165	–	–	–	–	2
Tin	SnO	573	$SnCl_2$	690	–	–	4
"	–	–	$SnCl_4$	1089	–	–	7
Zinc	ZnO	1185	–	–	–	–	4
"	"	1314	$ZnCl_2$	1495	–	–	1

Substance.	Combined with $S+O_4$ to form —	Heat units.	Combined with $N+O_3$ to form —	Heat units.	Combined with $C+O_3$ to form —	Heat units.	Authority.
Calcium	$CaSO_4$	7997	$Ca(NO_3)_2$	5080	$CaCO_3$	6730	1
Copper	$CuSO_4$	2887	$Cu(NO_3)_2$	1304	–	–	1
Hydrogen	H_2SO_4	96450	HNO_3	41500	–	–	1
Iron	$FeSO_4$	4208	$Fe(NO_3)_2$	2134	–	–	1
Lead	$PbSO_4$	1047	$Pb(NO_3)_2$	512	$PbCO_3$	814	1
Magnesium	$MgSO_4$	12596	–	–	–	–	1
Mercury	–	–	–	–	–	–	1
Potassium	K_2SO_4	4416	KNO_3	3061	K_2CO_3	3583	1
Silver	Ag_2SO_4	776	$AgNO_3$	266	Ag_2CO_3	561	1
Sodium	Na_2SO_4	7119	$NaNO_3$	4834	Na_2CO_3	5841	1
Zinc	$ZnSO_4$	3538	–	–	–	–	1

AUTHORITIES.

1 Thomsen.
2 Berthelot.
3 Favre and Silbermann.
4 Joule.
5 Hess.
6 Average of seven different.
7 Andrews.
8 Woods.

* Combustion at constant pressure.

COMBINATION.

caused to combine with oxygen or the negative radical, the numbers indicate the amount of water, in the same from 0° to 1° C. by the addition of that heat.

Substance.	In dilute solutions.						Authority.
	Forms —	Heat units.	Forms —	Heat units.	Forms —	Heat units.	
Calcium	$CaOH_2O$	3734	$CaCl_2H_2O$	4690	$CaS + H_2O$	2457	1
Carbon — Diamond	–	–	–	–	–	–	2
" "	–	–	–	–	–	–	3
" — Graphite	–	–	–	–	–	–	3
Chlorine	–	–	–	–	–	–	1
Copper	–	–	–	–	–	–	1
"	–	–	–	–	–	–	1
"	–	–	–	–	–	–	4
Hydrogen	–	–	–	–	–	–	3
"	–	–	–	–	–	–	5
"	–	–	–	–	–	–	6
Iron	$FeO + H_2O$	1220*	$FeCl_2 + H_2O$	1785	–	–	3
"	–	–	$FeCl_3$	2280	–	–	3
Iodine	–	–	–	–	–	–	1
Lead	–	–	$PbCl_2$	368	–	–	1
Magnesium	MgO_2H_2	9050†	$MgCl_2$	7779	MgS	4784	1
Manganese	–	–	$MnCl_2$	2327	–	–	1
Mercury	–	–	–	–	–	–	1
"	–	–	$HgCl_2$	299	–	–	1
Nitrogen	–	–	–	–	–	–	1
"	–	–	–	–	–	–	1
"	–	–	–	–	–	–	1
Phosphorus (red)	–	–	–	–	–	–	1
" (yellow)	–	–	–	–	–	–	7
" "	–	–	–	–	–	–	1
Potassium	K_2O	2110*	KCl	2592	K_2S	1451	8
Silver	–	–	–	–	–	–	1
Sodium	Na_2O	3375	$NaCl$	4190	Na_2S	2260	8
Sulphur	–	–	–	–	–	–	1
"	–	–	–	–	–	–	2
Tin	–	–	$SnCl_2$	691	–	–	7
"	–	–	$SnCl_4$	1344	–	–	7
Zinc	–	–	–	–	–	–	4
"	–	–	$ZnCl_2$	1735	–	–	1

Substance.	In dilute solutions.						Authority.
	Forms —	Heat units.	Forms —	Heat units.	Forms —	Heat units.	
Calcium	–	–	$Ca(NO_3)_2$	5175	–	–	1
Copper	$CuSO_4$	3150	$Cu(NO_3)_2$	1310	–	–	1
Hydrogen	H_2SO_4	105300	HNO_3	24550	–	–	1
Iron	$FeSO_4$	4210	$Fe(NO_3)_3$	2134	–	–	1
Lead	–	–	$Pb(NO_3)_2$	475	–	–	1
Magnesium	$MgSO_4$	13420	$Mg(NO_3)_2$	8595	–	–	1
Mercury	–	–	$Hg(NO_3)_2$	335	–	–	1
Potassium	K_2SO_4	4324	KNO_3	2860	–	–	1
Silver	Ag_2SO_4	753	$AgNO_3$	216	–	–	1
Sodium	Na_2SO_4	7160	$NaNO_3$	4620	Na_2CO_3	5995	1
Zinc	$ZnSO_4$	3820	$Zn(NO_3)_2$	2035	–	–	1

AUTHORITIES.

1 Thomsen. 2 Berthelot. 3 Favre and Silbermann. 4 Joule. 5 Hess. 6 Average of seven different. 7 Andrews. 8 Woods.

* Thomsen. † Total heat from elements.

LATENT HEAT OF VAPORIZATION.

The temperature of vaporization in degrees Centigrade is indicated by T; the latent heat in calories per kilogramme or in therms per gramme by H; the total heat from 0° C. in the same units by H'. The pressure is that due to the vapor at the temperature T.

Substance.	Formula.	T	H	H'	Authority.
Acetic acid	$C_2H_4O_2$	118°	84.9	–	Ogier.
Alcohol: Amyl	$C_5H_{12}O$	131	120	–	Schall.
Ethyl	C_2H_6O	–	209	–	Favre and Silbermann.
"	"	78.1	205	255	Wirtz.
"	"	0	236	236	Regnault.
"	"	50	–	264	"
"	"	100	–	267	"
"	"	150	–	285	"
Methyl	CH_4O	64.5	2.67	307	Wirtz.
"	"	0	289	289	Ramsay and Young.
"	"	50	–	274	" " "
"	"	100	–	246	" " "
"	"	150	–	206	" " "
"	"	200	–	152	" " "
"	"	238.5	–	44.2	" " "
Ammonia	NH_3	7.8	294.2	–	Regnault.
"	"	11	291.3	–	"
"	"	16	297.4	–	"
"	"	17	296.5	–	"
Benzene	C_6H_6	80.1	92.9	127.9	Wirtz.
Bromine	Ba	88	45.6	–	Andrews.
Carbon dioxide, solid	CO_2	–	–	138.7	Favre.
liquid	"	–25	72.23	–	Cailletet and Mathias.
" " "	"	0	57.48	–	" " "
" " "	"	12.35	44.97	–	Mathias.
" " "	"	22.04	31.8	–	"
" " "	"	29.85	14.4	–	"
" " "	"	30.82	3.72	–	"
" disulphide	CS_2	46.1	83.8	94.8	Wirtz.
" "	"	0	90	90	Regnault.
" "	"	100	–	100.5	"
" "	"	140	–	102.4	"
Chloroform	$CHCl_3$	60.9	58.5	78.8	Wirtz.
Ether	$C_4H_{10}O$	34.5	88.4	107	"
"	"	34.9	90.5	–	Andrews.
"	"	0	94	94	Regnault.
"	"	50	–	115.1	"
"	"	120	–	140	"
Iodine	I	–	2.95	–	Favre and Silbermann.
Sulphur dioxide	SO_2	0	91.2	–	Cailletet and Mathias.
" "	"	30	80.5	–	" " "
" "	"	65	68.4	–	" " "
Turpentine	$C_{10}H_{16}$	159.3	74.04	–	Brix.
Water	H_2O	100	535.9	–	Andrews.
"	"	100	–	637	Regnault.

LATENT HEAT OF VAPORIZATION.*

Substance, formula, and temperature.	l = total heat from fluid at 0° to vapor at t°. r = latent heat at t°.	Authority.
Acetone, C_3H_6O, − 3° to 147°.	$l = 140.5 + 0.36644\,t - 0.000516\,t^2$ $l = 139.9 + 0.23356\,t + 0.00055358\,t^2$ $r = 139.9 - 0.27287\,t + 0.0001571\,t^2$	Regnault. Winkelmann. "
Benzene, C_6H_6, 7° to 215°.	$l = 109.0 + 0.24429\,t - 0.0001315\,t^2$	Regnault.
Carbon dioxide, CO_2, − 25° to 31°.	$r^2 = 118.485\,(31 - t) - 0.4707\,(31 - t)^2$	Cailletet and Mathias.
Carbon disulphide, CS_2, − 6° to 143°.	$l = 90.0 + 0.14601\,t - 0.0004123\,t^2$ $l = 89.5 + 0.16993\,t - 0.0010161\,t^2 + 0.000003424\,t^3$ $r = 89.5 - 0.06530\,t - 0.0010976\,t^2 + 0.000003424\,t^3$	Regnault. Winkelmann. "
Carbon tetrachloride, CCl_4, 8° to 163°.	$l = 52.0 + 0.14625\,t - 0.000172\,t^2$ $l = 51.9 + 0.17867\,t - 0.0009599\,t^2 + 0.000003733\,t^3$ $r = 51.9 - 0.01931\,t - 0.0010505\,t^2 + 0.000003733\,t^3$	Regnault. Winkelmann. "
Chloroform, $CHCl_3$, − 5° to 159°.	$l = 67.0 + 0.1375\,t$ $l = 67.0 + 0.14716\,t - 0.0000437\,t^2$ $r = 67.0 - 0.08519\,t - 0.0001444\,t^2$	Regnault. Winkelmann. "
Nitrous oxide, N_2O, − 20° to 36°.	$r^2 = 131.75\,(36.4 - t) - 0.928\,(36.4 - t)^2$	Cailletet and Mathias.
Sulphur dioxide, SO_2, 0° to 60°.	$r = 91.87 - 0.3842\,t - 0.000340\,t^2$	Mathias.

* Quoted from Landolt and Boernstein's "Phys. Chem. Tab." p. 350.

LATENT HEAT OF FUSION.

This table contains the latent heat of fusion of a number of solid substances. It has been compiled principally from Landolt and Boernstein's tables. *C* indicates the composition, *T* the temperature Centigrade, and *H* the latent heat.

Substance.	*C*	*T*	*H*	Authority.
Alloys: 30.5Pb + 69.5Sn	$PbSn_4$	183	17	Spring.
36.9Pb + 61.3Sn	$PbSn_3$	179	15.5	"
63.7Pb + 36.3Sn	PbSn	177.5	11.6	"
77.8Pb + 22.2Sn	Pb_2Sn	176.5	9.54	"
Britannia metal, 9Sn + 1Pb	–	236	28.0*	Ledebur.
Rose's alloy, 24Pb + 27.3Sn + 48.7Bi	–	98.8	6.85	Mazzotto.
Wood's alloy {25.8Pb + 14.7Sn + 52.4Bi + 7Cd}	–	75.5	8.40	"
Bromine	Br	—7.32	16.2	Regnault.
Bismuth	Bi	266.8	12.64	Person.
Benzene	C_6H_6	5.3	30.85	Fischer.
Cadmium	Cd	320.7	13.66	Person.
Calcium chloride	$CaCl_2 + 6H_2O$	28.5	40.7	"
Iron, Gray cast	–	–	23	Gruner.
White "	–	–	33	"
Slag	–	–	50	"
Iodine	I	–	11.71	Favre and Silbermann.
Ice	H_2O	0	79.24	Regnault.
"	"	0	80.02	Bunsen.
" (from sea-water)	{H_2O + 3.535 of solids}	—8.7	54.0	Petterson.
Lead	Pb	325	5.86	Rudberg.
Mercury	Hg	–	2.82	Person.
Naphthalene	$C_{10}H_8$	79.87	35.62	Pickering.
Palladium	Pd	(1500)?	36.3	Violle.
Phosphorus	P	40.05	4.97	Petterson.
Potassium nitrate	KNO_3	333.5	48.9	Person.
Phenol	C_6H_6O	25.37	24.93	Petterson.
Paraffin	–	52.40	35.10	Batelli.
Silver	Ag	999	21.07	Person.
Sodium nitrate	$NaNO_3$	305.8	64.87	"
Sodium phosphate	{$Na_2HPO_4 + 12H_2O$}	36.1	66.8	"
Spermaceti	–	43.9	36.98	Batelli.
Sulphur	S	115	9.37	Person.
Wax (bees)	–	61.8	42.3	"
Zinc	Zn	415.3	28.13	"

* Total heat from 0° C.

TABLE 215.

MELTING-POINT OF CHEMICAL ELEMENTS.

The melting-points of the chemical elements are in many cases somewhat uncertain, owing to the very different results obtained by different observers. This table gives the extreme values recorded except in a few cases where one observation differed so much from all others as to make its accuracy extremely improbable. The column headed "Mean" gives a probable average value.

Substance.	Range. Min.	Range. Max.	Mean.	Observer.	Substance.	Range. Min.	Range. Max.	Mean.	Observer.
	C.°	C.°	C.°			C.°	C.°	C.°	
Aluminium	600.	850.	625.		Lithium	–	–	180.	13
Antimony	425.	450.	435.		Magnesium	750.	800.	775.	13
Arsenic	bet. Sb and Ag			1	Manganese	–	–	1900.	14
Barium	above that of cast iron			2	Mercury	—38.50	—39.44	—39.04	
Beryllium	below that of silver			3	Molybdenum	above white heat			15
Bismuth	266.8	269.2	268.1		Nickel	1450.	1600.	1500.	
Boron, amorph.	melts in elect. arc			4	Osmium	–	–	2500.	16
Bromine	—7.2	—7.3	—7.27		Nitrogen	—203.	—214.	—208.	
Cadmium	315.	321.	318.		Palladium	1350.	1950.	1600.	
Cæsium	–	–	26.5	5	Phosphorus	44.2	44.4	44.25	
Chlorine, liquid	–	–	—102.	6	Platinum	1775.	2200.	1900.	
Chromium	above that of platinum			7	Potassium	55.	63.	60.	
Cobalt	1500.	1800.	1650.		Rhodium	–	–	2000.	16
Copper	1050.	1330.	1100.		Rubidium	–	–	38.5	
Gallium	–	–	30.15	8	Ruthenium	–	–	1800.	
Germanium	–	–	900.	9	Silenium	–	–	217.	17
Gold	1035.	1250.	1080.		Silicon	bet. cast iron and steel			7
Indium	–	–	176.	10	Silver	916.	1040.	950.	
Iodine	107.	115.	112.		Sodium	95.6	—97.6	97.6	
Iridium	1950.	1500.	2225.		Strontium	red heat			18
Iron (pure)	1500.	1800.	1635.		Sulphur	111.	120.	115.1	
" (white pig)	1050.	1100.	1075.		Tellurium	452.	525.	470.	
" (gray pig)	1100.	2275.	1200.		Thallium	288.	290.	289.	
Steel	1300.	1400.	1360.		Tin	226.5	235.	230.	
" (cast)	–	–	1375.	11	Tungsten	above that of manganese			19
Lanthanum	between Sb and Ag			12	Zinc	400.	433.	415.	
Lead	322.	335.	326.						

1 Mallet. 2 Frey. 3 Debray. 4 Despretz. 5 Setterberg, 1882. 6 Olszewski, 1884. 7 Deville, 1856. 8 Lecoq de Boisbaudran, 1876. 9 Winkler, 1886. 10 Winkler, 1867. 11 Ledebur, 1881. 12 Hildebrand and Norton, 1875. 13 Bunsen. 14 Carnelley, 1879. 15 Buchholz. 16 Pictet, 1879. 17 Hittorf, 1851. 18 Matthieson, 1855. 19 Wöhler.

TABLE 216.

BOILING-POINT OF CHEMICAL ELEMENTS.

The column headed "Range" gives the extremes of the records found. Where the results are from one observer the authority is quoted with date of publication.

Substance.	Range. Min.	Range. Max.	Mean.	Observer.	Substance.	Range. Min.	Range. Max.	Mean.	Observer.
Aluminium	above white heat			1	Nitrogen	–	–	—194.4	8
Antimony	1470.	1700.	1535.		Oxygen	—181.	—184.	—183.	
Arsenic	449.	450.	–	2	Ozone	–	–	—106.	9
Bismuth	1090.	1700.	1413.		Phosphorus	287.3	290.	288.	
Bromine	59.27	63.05	62.08		Potassium	667.	725.	695.	
Cadmium	720.	860.	779.		Selenium	664.	683.	675.	
Chlorine	–	–	—33.6	3	Sodium	742.	907.	825.	
Iodine	over 200°			4	Sulphur	447.	448.4	448.1	
Lead	bet. 1450° and 1600°			5	Thallium	1600.	1800.	1700.	
Magnesium	–	–	1100.	6	Tin	bet. 1450° and 1600°			
Mercury	–	–	357.	7	Zinc	891.	1040.	958.	

1 Deville, 1854. 2 Conechy. 3 Regnault, 1863. 4 Stas, 1865. 5 Carnelley, 1879. 6 Ditte, 1871. 7 Regnault, 1862. 8 Olszewski, 1884. 9 Olszewski, 1887.

Table 217.

MELTING-POINTS OF VARIOUS INORGANIC COMPOUNDS.*

Substance.	Chemical formula.	Melting-points. Min.	Max.	Particular or average values.	Authority.	Date of publication.
Aluminium chloride	$AlCl_3$	–	–	190.	1	1888
" nitrate	$Al(NO_3)_3 + 9H_2O$	–	–	72.8	2	1859
Ammonia	NH_3	–	–	–75.	3	1875
Ammonium nitrate	$(NH_4)NO_3$	145.	166.	156.	–	–
" sulphate	$(NH_4)_2SO_4$	–	–	140.	4	1837
" phosphite	$NH_4H_2PO_3$	–	–	123.	5	1887
Antimonietted hydrogen	SbH_3	–	–	–91.5	6	1886
Antimony trichloride	$SbCl_3$	72.	73.2	72.8	–	–
" pentachloride	$SbCl_5$	–	–	–6.	7	1875
Arsenic trichloride	$AsCl_3$	–	–	–18.	8	1889
Arseniette hydrogen	AsH_3	–	–	–113.5	6	1884
Barium chlorate	$Ba(ClO_3)_2$	–	–	414.	9	1878
" nitrate	$Ba(NO_3)_2$	–	–	593.	9	1878
" perchlorate	$Ba(ClO_4)_2$	–	–	505.	10	1884
Bismuth trichloride	$BiCl_3$	225.	230.	227.5	11	1876
Boric acid	H_3BO_3	184.	186.	185.	9	1878
" anhydride	B_2O_3	–	–	577.	9	1878
Borax (sodium borate)	$Na_2B_4O_7$	–	–	561.	9	1878
Cadmium chloride	$CdCl_2$	–	–	541.	9	1878
" nitrate	$Cd(NO_3)_2 + 4H_2O$	–	–	59.5	2	1859
Calcium chloride	$CaCl_2$	719.	723.	721.	9	1878
" "	$CaCl_2 + 6H_2O$	28.	29.	28.5	–	–
" nitrate	$Ca(NO_3)_2$	–	–	561.	9	1878
" "	$Ca(NO_3)_2 + 4H_2O$	–	–	44.	2	1859
Carbon tetrachloride	CCl_4	–	–	–24.7	12	1863
" trichloride	C_2Cl_6	182.	187.	184.5	–	–
" monoxide	CO	–199.	–207.	203.	–	–
" dioxide	CO_2	–56.5	–57.5	–57.	3	1845
" disulphide	CS_2	–	–	–110.	13	1883
Chloric acid	$HClO_4 + H_2O$	–	–	50.	14	1861
Chlorine dioxide	ClO_2	–	–	–76.	3	1845
Chrome alum	$KCr(SO_4)_2 + 12H_2O$	–	–	89.	15	1884
Chrome nitrate	$Cr_2(NO_3)_6 + 18H_2O$	–	–	37.	2	1859
Cobalt sulphate	$CoSO_4$	96.	98.	97.	15	1884
Cupric chloride	$CuCl_2$	–	–	498.	9	1878
Cuprous "	Cu_2Cl_2	–	–	434.	9	1878
" nitrate	$Cu(NO_3)_2 + 2H_2O$	–	–	114.5	2	1859
Hydrobromic acid	HBr	–	–	–86.7	3	1845
Hydrochloric acid	HCl	–	–	–112.5	6	1884
Hydrofluoric acid	HFl	–	–	–92.3	6	1886
Hydroiodic acid	HI	–	–	–49.5	3	1845
Hydrogen peroxide	H_2O_2	–	–	–30.	16	1818
" phosphide	PH_3	–	–	–132.5	6	1886
" sulphide	H_2S	–	–	–85.6	3	1845
Iron chloride	$FeCl_3$	301.	307.	303.	–	–
" nitrate	$Fe(NO_3)_3 + 9H_2O$	–	–	47.2	2	1859
" sulphate	$FeSO_4 + 7H_2O$	–	–	64.	15	1884
Lead chloride	$PbCl_2$	498.	580.	526.	–	–
" metaphosphate	$Pb(PO_3)_2$	–	–	800.	9	1878
Magnesium chloride	$MgCl_2$	–	–	708.	9	1878
" nitrate	$Mg(NO_3)_2 + 6H_2O$	–	–	90.	2	1859
" sulphate	$MgSO_4 + 5H_2O$	–	–	54.	15	1884
Manganese chloride	$MnCl_2 + 4H_2O$	–	–	87.5	17	–
" nitrate	$Mn(NO_3)_2 + 6H_2O$	–	–	25.8	2	1859
" sulphate	$MnSO_4 + 5H_2O$	–	–	54.	15	1884
Mercuric chloride	$HgCl_2$	287.	293.	290.	–	–

1 Friedel and Crafts. 2 Ordway. 3 Faraday. 4 Marchand. 5 Amat. 6 Olszewski. 7 Kammerer. 8 Besson. 9 Carnelley. 10 Carnelley and O'Shea. 11 Muir. 12 Regnault. 13 Wroblewski and Olszewski. 14 Roscoe. 15 Tilden. 16 Thénard. 17 Clark, "Const. of Nat."

* For more extensive tables on this subject, see Carnelley's "Melting and Boiling-point Tables," or Landolt and Boernstein's "Phys. Chem. Tab."

MELTING-POINTS OF VARIOUS INORGANIC COMPOUNDS.

Substance.	Chemical formulæ.	Melting-point. Min.	Max.	Particular or probable value.	Authority.	Date of publication.
Nickel carbonyl	$NiCO_4$	-	-	—25.	1	1890
" nitrate	$Ni(NO_3)_2 + 6H_2O$	-	-	56.7	2	1859
" sulphate	$NiSO_4 + 7H_2O$	98.	100.	99.	3	1884
Nitric acid	HNO_3	-	-	—47.	4	1878
" anhydride	N_2O_5	-	-	30.	5	1872
" oxide *	NO	-	-	—16.7	6	1885
" peroxide	N_2O_4	-	-	—10.14	7	1890
Nitrous anhydride	N_2O_3	-	-	—82.	8	1889
" oxide	N_2O	-	-	—99.	9	1873
Phosphoric acid (ortho)	H_3PO_4	38.6	41.7	40.3	-	-
Phosphorous acid	H_3PO_3	70.1	74.	72.	-	-
Phosphorus trichloride	PCl_3	-	-	111.8	10	1883
" oxychloride	$PClO_3$	-	-	—1.5	11	1871
" disulphide	PS_2	296.	298.	297.	12	1879
" pentasulphide	P_2S_5	274.	276.	275.	13	1879
" sesquisulphide	P_4S_3	142.	167.	158.	-	-
" trisulphide	P_2S_3	-	-	290.	14	1864
Potassium carbonate	K_2CO_3	834.	1150. ?	836.	-	-
" chlorate	$KClO_3$	334.	372.	354.	-	-
" perchlorate	$KClO_4$	-	-	610.	15	1880
" chloride	KCl	730.	738.	734.	-	-
" nitrate	KNO_3	327.	353.	340.	-	-
" acid phosphate	KH_2PO_4	-	-	96.	3	1884
" acid sulphate	$KHSO_4$	-	-	200.	16	1840
Silver chloride	$AgCl$	450.	457.	453.	-	-
" nitrate	$AgNO_3$	198.	224.	214.	-	-
" nitrogeniетted	AgN_3	-	-	250.	20	1890
" perchlorate	$AgClO_4$	-	-	486.	18	1884
" phosphate	Ag_3PO_4	-	-	849.	15	1878
" metaphosphate	$AgPO_3$	-	-	482.	15	1878
" sulphate	Ag_2SO_4	-	-	654.	15	1878
Sodium chloride	$NaCl$	772.	960.	772.	-	-
" hydroxide	$NaOH$	-	-	60.	17	1884
" nitrate	$NaNO_3$	298.	330.	315.	-	-
" chlorate	$NaClO_3$	-	-	302.	15	1878
" perchlorate	$NaClO_4$	-	-	482.	18	1884
" carbonate	Na_2CO_3	814.	920.	884.	-	-
" "	$Na_2CO_3 + 10H_2O$	-	-	34.	3	1884
" phosphate	$Na_2HPO_4 + 4H_2O$	35.	36.4	35.4	-	-
" metaphosphate	$NaPO_3$	-	-	617.	15	1878
" pyrophosphate	$Na_4P_2O_7$	-	-	888.	15	1878
" phosphite	$(H_2NaPO_3)_2 + 5H_2O$	-	-	42.	19	1888
" sulphate	Na_2SO_4	861.	865.	863.	15	1878
" "	$Na_2SO_4 + 10H_2O$	-	-	34.	3	1884
" hyposulphite	$Na_2S_2O_3 + 5H_2O$	45.	48.1	47.	-	-
Sulphur dioxide	SO_2	76.	79.	78.	-	-
Sulphuric acid	H_2SO_4	10.1	10.6	10.4	21	1884
" "	$12H_2SO_4 + H_2O$	-	-	—0.5	22	1853
" "	$H_2SO_4 + H_2O$	7.5	8.5	8.	-	-
" " (pyro)	$H_2S_2O_7$	-	-	35.	22	1853
Sulphur trioxide	SO_3	14.8	15.	14.9	5	1876–1886
Tin, stannic chloride	$SnCl_4$	-	-	—33.	23	1889
" stannous "	$SnCl_2$	-	-	250.	24	-
Zinc chloride	$ZnCl_2$	-	-	262.	25	1875
" "	$ZnCl_2 + 3H_2O$	-	-	7.	26	1886
" nitrate	$Zn(NO_3)_2 + 6H_2O$	-	-	36.4	3	1884
" sulphate	$ZnSO_4 + 7H_2O$	-	-	50.	3	1884

1 Mond, Langer & Quincke. 2 Ordway. 3 Tilden. 4 Berthelot. 5 R. Weber. 6 Olszewski. 7 Ramsay. 8 Birhaus. 9 Wills. 10 Wroblewski & Olszewski. 11 Genther & Michaelis. 12 Ramme. 13 V. & C. Meyer. 14 Lemoine. 15 Carnelley. 16 Mitscherlich. 17 Cripps. 18 Carnelley & O'Shea. 19 Amat. 20 Curtius. 21 Mendelejeff. 22 Marignac. 23 Besson. 24 Clark, "Const. of Nat." 25 Braun. 26 Engel.

* Under pressure 138 mm. mercury.

LATENT HEAT OF VAPORIZATION.

The temperature of vaporization in degrees Centigrade is indicated by T; the latent heat in calories per kilogramme or in therms per gramme by H; the total heat from 0° C. in the same units by H'. The pressure is that due to the vapor at the temperature T.

Substance.	Formula.	T	H	H'	Authority.
Acetic acid	$C_2H_4O_2$	118°	84.9	–	Ogier.
Alcohol: Amyl	$C_5H_{12}O$	131	120	–	Schall.
Ethyl	C_2H_6O	–	209	–	Favre and Silbermann.
"	"	78.1	205	255	Wirtz.
"	"	0	236	236	Regnault.
"	"	50	–	264	"
"	"	100	–	267	"
"	"	150	–	285	"
Methyl	CH_4O	64.5	2.67	307	Wirtz.
"	"	0	289	289	Ramsay and Young.
"	"	50	–	274	" " "
"	"	100	–	246	" " "
"	"	150	–	206	" " "
"	"	200	–	152	" " "
"	"	238.5	–	44.2	" " "
Ammonia	NH_3	7.8	294.2	–	Regnault.
"	"	11	291.3	–	"
"	"	16	297.4	–	"
"	"	17	296.5	–	"
Benzene	C_6H_6	80.1	92.9	127.9	Wirtz.
Bromine	Ba	88	45.6	–	Andrews.
Carbon dioxide, solid	CO_2	–	–	138.7	Favre.
liquid	"	–25	72.23	–	Cailletet and Mathias.
" " "	"	0	57.48	–	" " "
" " "	"	12.35	44.97	–	Mathias.
" " "	"	22.04	31.8	–	"
" " "	"	29.85	14.4	–	"
" " "	"	30.82	3.72	–	"
" disulphide	CS_2	46.1	83.8	94.8	Wirtz.
" "	"	0	90	90	Regnault.
" "	"	100	–	100.5	"
" "	"	140	–	102.4	"
Chloroform	$CHCl_3$	60.9	58.5	78.8	Wirtz.
Ether	$C_4H_{10}O$	34.5	88.4	107	"
"	"	34.9	90.5	–	Andrews.
"	"	0	94	94	Regnault.
"	"	50	–	115.1	"
"	"	120	–	140	"
Iodine	I	–	2.95	–	Favre and Silbermann.
Sulphur dioxide	SO_2	0	91.2	–	Cailletet and Mathias.
" "	"	30	80.5	–	" " "
" "	"	65	68.4	–	" " "
Turpentine	$C_{10}H_{10}$	159.3	74.04	–	Brix.
Water	H_2O	100	535.9	–	Andrews.
"	"	100	–	637	Regnault.

LATENT HEAT OF VAPORIZATION.*

Substance, formula, and temperature.	l = total heat from fluid at 0° to vapor at $t°$. r = latent heat at $t°$.	Authority.
Acetone, C_3H_6O, $-3°$ to $147°$.	$l = 140.5 + 0.36644\,t - 0.000516\,t^2$ $l = 139.9 + 0.23356\,t + 0.00055358\,t^2$ $r = 139.9 - 0.27287\,t + 0.0001571\,t^2$	Regnault. Winkelmann. "
Benzene, C_6H_6, $7°$ to $215°$.	$l = 109.0 + 0.24429\,t - 0.0001315\,t^2$	Regnault.
Carbon dioxide, CO_2, $-25°$ to $31°$.	$r^2 = 118.485\,(31 - t) - 0.4707\,(31 - t^2)$	Cailletet and Mathias.
Carbon disulphide, CS_2, $-6°$ to $143°$.	$l = 90.0 + 0.14601\,t - 0.000412\,t^2$ $l = 89.5 + 0.16993\,t - 0.0010161\,t^2 + 0.000003424\,t^3$ $r = 89.5 - 0.06530\,t - 0.0010976\,t^2 + 0.000003424\,t^3$	Regnault. Winkelmann. "
Carbon tetrachloride, CCl_4, $8°$ to $163°$.	$l = 52.0 + 0.14625\,t - 0.000172\,t^2$ $l = 51.9 + 0.17867\,t - 0.0009599\,t^2 + 0.000003733\,t^3$ $r = 51.9 - 0.01931\,t - 0.0010505\,t^2 + 0.000003733\,t^3$	Regnault. Winkelmann. "
Chloroform, $CHCl_3$, $-5°$ to $159°$.	$l = 67.0 + 0.1375\,t$ $l = 67.0 + 0.14716\,t - 0.0000437\,t^2$ $r = 67.0 - 0.08519\,t - 0.0001444\,t^2$	Regnault. Winkelmann. "
Nitrous oxide, N_2O, $-20°$ to $36°$.	$r^2 = 131.75\,(36.4 - t) - 0.928\,(36.4 - t)^2$	Cailletet and Mathias.
Sulphur dioxide, SO_2, $0°$ to $60°$.	$r = 91.87 - 0.3842\,t - 0.000340\,t^2$	Mathias.

* Quoted from Landolt and Boernstein's "Phys. Chem. Tab." p. 350.

TABLE 220.

DENSITIES, MELTING-POINTS, AND BOILING-POINTS OF SOME ORGANIC COMPOUNDS.

N. B. — The data in this table refer only to normal compounds.

Substance.	Formula.	Temp. ° C.	Density.	Melting-point.	Boiling-point.	Authority.
			(a) Paraffin Series: C_nH_{2n+2}.			
Methane*	CH_4	—164.	0.415	—185.8	—164.	Olszewski.
Ethane†	C_2H_6	-	-	-	-	
Propane	C_3H_8	-	-	-	—25 to —30	Roscoe and Schorlemmer.
Butane	C_4H_{10}	0	.60	-	+1.	Butlerow.
Pentane	C_5H_{12}	17.	.626	-	+37.	Schorlemmer.
Hexane	C_6H_{14}	17.	.663	-	+69.	"
Heptane	C_7H_{16}	0	.701	-	98.4	Thorpe.
Octane	C_8H_{18}	0	.719	-	125.5	"
Nonane	C_9H_{20}	20.	.718	—51.	150.	Krafft.
Decane	$C_{10}H_{22}$	20.	.730	—31.	173.	"
Undecane	$C_{11}H_{24}$	—26.	.774	—26.	195.	"
Dodecane	$C_{12}H_{26}$	—12.	.773	—12.	214.	"
Tridecane	$C_{13}H_{28}$	—6.	.775	—6.	234.	"
Tetradecane	$C_{14}H_{30}$	+4.	.775	+4.	252.	"
Pentadecane	$C_{15}H_{32}$	10.	.776	+10.	270.	"
Hexadecane	$C_{16}H_{34}$	18.	.775	18.	287.	"
Heptadecane	$C_{17}H_{36}$	22.	.777	22.	303.	"
Octadecane	$C_{18}H_{38}$	28.	.777	28.	317.	"
Nonadecane	$C_{19}H_{40}$	32.	.777	32.	330.	"
Eicosane	$C_{20}H_{42}$	37.	.778	37.	205.‡	"
Heneicosane	$C_{21}H_{44}$	40.	.778	40.	215.‡	"
Docosane	$C_{22}H_{46}$	44.	.778	44.	224.‡	"
Tricosane	$C_{23}H_{48}$	48.	.779	48.	234.‡	"
Tetracosane	$C_{24}H_{50}$	51.	.779	51.	243.‡	"
Heptacosane	$C_{27}H_{56}$	60.	.780	60.	270.‡	"
Pentriacontane	$C_{31}H_{64}$	68.	.781	68.	302.‡	"
Dicetyl	$C_{32}H_{66}$	70.	.781	70.	310.‡	"
Penta-tria-contane	$C_{35}H_{72}$	75.	.782	75.	331.‡	"
			(b) Olefines, or the Ethylene Series: C_nH_{2n}.			
Ethylene	C_2H_4	-	-	—169.	—103.	Wroblewski or Olszewski.
Propylene	C_3H_6	-	-	-	-	
Butylene	C_4H_8	—13.5	0.635	-	1.	Sieben.
Amylone	C_5H_{10}	-	-	-	36.	Wagner or Saytzeff.
Hexylene	C_6H_{12}	0	.76	-	69.	Wreden or Znatowicz.
Heptylene	C_7H_{14}	19.5	.703	-	96.–99.	Morgan or Schorlemmer.
Octylene	C_8H_{16}	17.	.722	-	122.–123.	Möslinger.
Nonylene	C_9H_{18}	-	-	-	153.	Bernthsen, "Org. Chem."
Decylene	$C_{10}H_{20}$	-	-	-	175.	" " "
Undecylene	$C_{11}H_{22}$	-	-	-	195.	" " "
Dodecylene	$C_{12}H_{24}$	—31.	.795	—31.	96.‡	Krafft.
Tridecylene	$C_{13}H_{26}$	-	-	-	233.	Bernthsen.
Tetradecylene	$C_{14}H_{28}$	—12.	.794	—12.	127.‡	Krafft.
Pentadecylene	$C_{15}H_{30}$	-	-	-	247.	Bernthsen.
Hexadecylene	$C_{16}H_{32}$	+4.	.792	+4.	155.‡	Krafft, Mendelejeff, etc.
Octadecylene	$C_{18}H_{36}$	18.	.791	+18.	179.‡	Krafft.
Eicosylene	$C_{20}H_{40}$	-	-	-	-	
Cerotene	$C_{27}H_{54}$	-	-	58.	-	Bernthsen.
Melene	$C_{30}H_{60}$	-	-	62.	-	"

* Liquid at — 11.° C. and 180 atmospheres' pressure (Cailletet).
† " +4.° " 46 " " "
‡ Boiling-point under 15 mm. pressure.

DENSITIES, MELTING-POINTS, AND BOILING-POINTS OF SOME ORGANIC COMPOUNDS.

Substance.	Chemical formula.	Temp. C°.	Specific gravity.	Melting-point.	Boiling-point.	Authority.
(c) Acetylene Series: C_nH_{2n-2}.						
Acetylene	C_2H_2	-	-	-	-	
Allylene	C_3H_4	-	-	-	-	
Ethylacetylene	C_4H_6	-	-	-	+ 18.	Bruylants, Kutscheroff, and others.
Propylacetylene	C_5H_8	-	-	-	48.–50.	Bruylants, Taworski.
Butylacetylene	C_6H_{10}	-	-	-	68.–70.	Taworski.
Oenanthylidene	C_7H_{12}	-	-	-	106.–108.	Bruylants, Behal, and others.
Caprylidene	C_8H_{14}	0.	0.771	-	133.–134.	Behal.
Undecylidene	$C_{11}H_{20}$	-	-	-	210.–215.	Bruylants.
Dodecylidene	$C_{12}H_{22}$	—9.	.810	— 9.	105.*	Krafft.
Tetradecylidene	$C_{14}H_{26}$	+ 6.5	.806	+ 6.5	134.*	"
Hexadecylidene	$C_{16}H_{30}$	20.	.804	20.	160.*	"
Octadecylidene	$C_{18}H_{34}$	30.	.802	30.	184.*	"
(d) Monatomic alcohols: $C_nH_{2n+1}OH$.						
Methyl alcohol	CH_3OH	0.	0.812	-	66.	
Ethyl alcohol	C_2H_5OH	0.	.806	—130.†	78.	
Propyl alcohol	C_3H_7OH	0.	.817	-	97.	From Zander, "Lieb.
Butyl alcohol	C_4H_9OH	0.	.823	-	117.	Ann." vol. 224, p. 85,
Amyl alcohol	$C_5H_{11}OH$	0.	.829	-	138.	and Krafft, "Ber."
Hexyl alcohol	$C_6H_{13}OH$	0.	.833	-	157.	vol. 16, 1714,
Heptyl alcohol	$C_7H_{15}OH$	0.	.836	-	176.	" 19, 2221,
Octyl alcohol	$C_8H_{17}OH$	0.	.839	-	195.	" 23, 2360,
Nonyl alcohol	$C_9H_{19}OH$	0.	.842	— 5.	213.	and also Wroblewski and Olszewski,
Decyl alcohol	$C_{10}H_{21}OH$	+ 7.	.839	+ 7.	231.	
Dodecyl alcohol	$C_{12}H_{25}OH$	24.	.831	24.	143.*	"Monatshefte,"
Tetradecyl alcohol	$C_{14}H_{29}OH$	38.	.824	38.	167.*	vol. 4, p. 338.
Hexadecyl alcohol	$C_{16}H_{33}OH$	50.	.818	50.	190.*	
Octadecyl alcohol	$C_{18}H_{37}OH$	59.	.813	59.	211.*	
(e) Alcoholic ethers: $C_nH_{2n+2}O$.						
Dimethyl ether	C_2H_6O	-	-	-	— 23.6	Erlenmeyer, Kreichbaumer.
Diethyl ether	$C_4H_{10}O$	4.	0.731	-	+ 34.6	Regnault.
Dipropyl ether	$C_6H_{14}O$	0.	.763	-	90.7	Zander and others.
Di-iso-propyl ether	$C_6H_{14}O$	0.	.743	-	69.	"
Di-n-butyl ether	$C_8H_{18}O$	0.	.784	-	141.	Lieben, Rossi, and others.
Di-sec-butyl ether	$C_8H_{18}O$	21.	.756	-	121.	Kessel.
Di-iso-butyl "	$C_8H_{18}O$	15.	.762	-	122.	Reboul.
Di-iso-amyl "	$C_{10}H_{22}O$	0.	.799	-	170.–175.	Wurtz.
Di-sec-hexyl "	$C_{12}H_{26}O$	-	-	-	203.–208.	Erlenmeyer and Wanklyn.
Di-norm-octyl "	$C_{16}H_{34}O$	17.	.805	-	280.–282.	Moslinger.
(f) Ethyl ethers: $C_nH_{2n+2}O$.						
Ethyl-methyl ether	C_3H_8O	-	-	-	11.	Wurtz, Williamson.
" propyl "	$C_5H_{12}O$	20.	0.739	-	63.–64.	Chancel, Brühl.
" iso-propyl ether	$C_5H_{12}O$	0.	.745	-	54.	Markownikow.
" norm-butyl ether	$C_6H_{14}O$	0.	.769	-	92.	Lieben, Rossi.
" iso-butyl ether	$C_6H_{14}O$	-	.751	-	78.–80.	Wurtz.
" iso-amyl ether	$C_7H_{16}O$	18.	.764	-	112.	Williamson and others.
" norm-hexyl ether	$C_8H_{18}O$	-	-	-	134.–137.	Lieben, Janeczek.
" norm-heptyl ether	$C_9H_{20}O$	16.	.790	-	165.	Cross.
" norm-octyl ether	$C_{10}H_{22}O$	17.	.794	-	182.–184.	Moslinger.

* Boiling-point under 15 mm. pressure.
† Liquid at —11.° C. and 180 atmospheres' pressure (Cailletet).

COEFFICIENTS OF THERMAL EXPANSION.

Coefficients of Linear Expansion of the Chemical Elements.

In the heading of the columns T is the temperature or range of temperature, C the coefficient of linear expansion, A_1 the authority for C, M the mean coefficient of expansion between 0° and 100° C., α and β the coefficients in the equation $l_t = l_0\,(1 + \alpha t + \beta t^2)$, where l_0 is the length at 0° C. and l_t the length at t° C., A_2 is the authority for α, β, and m.

Substance.	T	$C \times 10^4$	A_1	$M \times 10^4$	$\alpha \times 10^4$	$\beta \times 10^6$	A_2
Aluminium . .	40	0.2313	Fizeau . . .	0.2220	-	-	Calvert, Johnson and Lowe.
" . .	600	.3150	Les Chatelier.				
Antimony:							
Parallel to cryst. axis	40	.1692	Fizeau.				
Perp. to axis .	40	.0882	"				
Mean	40	.1152	" . . .	.1056	.0923	.0132	Matthieson.
Arsenic	40	.0559	"				
Bismuth:							
Parallel to axis	40	.1621	"				
Perp. to axis .	40	.1208	"				
Mean	40	.1346	" . . .	.1316	.1167	.0149	Matthieson.
Cadmium . . .	40	.3069	" . . .	.3159	.2693	.0466	"
Carbon:							
Diamond . . .	40	.0118	"				
Gas carbon . .	40	.0540	"				
Graphite . . .	40	.0786	"				
Anthracite . .	40	.2078	"				
Cobalt	40	.1236	"				
Copper	40	.1678	" . . .	.1666	.1481	.0185	Matthieson.
Gold	40	.1443	" . . .	.1470	.1358	.0112	"
Indium	40	.4170	"				
Iron:							
Soft	40	.1210	"				
Cast	40	.1061	"				
Wrought . . .	—18 to 100	.1140	Andrews.				
Steel	40	.1322	Fizeau.				
" annealed	40	.1095	" . . .	.1089	.1038	.0052	Benoit.
Lead	40	.2924	" . . .	.2709	.0273	.0074	Matthieson.
Magnesium . .	40	.2694	"				
Nickel	40	.1279	"				
Osmium . . .	40	.0657	"				
Palladium . . .	40	.1176	" . . .	.1104	.1011	.0093	Matthieson.
Phosphorus . .	0–40	1.2530	Pisati and De Franchis.				
Platinum . . .	40	.0899	Fizeau . . .	.0886	.0851	.0035	Matthieson.
Potassium . . .	0–50	.8300	Hagen.				
Rhodium . . .	40	.0850	Fizeau.				
Ruthenium . . .	40	.0960	"				
Selenium . . .	40	.3680	" . . .	.6604	-	-	Spring.
Silicon	40	.0763	"				
Silver	40	.1921	" . . .	.1943	.1809	.0135	Matthieson.
Sulphur:							
Cryst. mean . .	40	.6413	" . . .	1.180	-	-	Spring.
Tellurium . . .	40	.1675	" . . .	.3687	-	-	"
Thallium . . .	40	.3021	"				
Tin	40	.2234	" . . .	.2296	.2033	.2063	Matthieson.
Zinc	40	.2918	" . . .	.2976	.2741	.0234	"

N. B. — The above table has been with a few exceptions compiled from the results published by Fizeau, "Comptes Rendus," vol. 68, and Matthieson, "Proc. Roy. Soc.," vol. 15.

COEFFICIENT OF THERMAL EXPANSION.

Coefficient of Linear Expansion for Miscellaneous Substances.

N. B. — The coefficient of cubical expansion may be taken as three times the linear coefficient. *T* is the temperature or range of temperature, *C* the coefficient of expansion, and *A* the authority.

Substance.	*T*	$C \times 10^4$	*A*	Substance.	*T*	$C \times 10^4$	*A*
Brass:							
Cast . . .	0–100°	0.1875	1	Platinum-silver:			
Wire . . .	"	0.1930	1	1Pt+2Ag	0–100°	0.1523	4
— . . .	"	.1783–.1930	2	Porcelain . .	20–790	0.0413	16
71.5Cu+27.7Zn+				" Bayeux .	1000–1400	0.0553	17
0.3Sn+0.5Pb	40	0.1859	3	Quartz:			
71Cu+29Zn .	0–100	0.1906	4	Parallel to axis .	0–80	0.0797	6
Bronze:				Perpend. to axis .	"	0.1337	6
3Cu+1Sn . .	16.6–100	0.1844	5	Speculum metal .	0–100	0.1933	1
" " . .	16.6–350	0.2116	5	Topaz:			
" " . .	16.6–957	0.1737	5	Parallel to lesser			
86.3Cu+9.7Sn+				horizontal axis	"	0.0832	8
4Zn	40	0.1782	3	Parallel to greater			
97.6Cu+2.2Sn+				horizontal axis	"	0.0836	8
0.2P, hard	0–80	0.1713	6	Parallel to verti-			
" " " " soft	"	0.1708	6	cal axis	"	0.0472	8
Caoutchouc . .	–	.657–.686	2	Tourmaline:			
" . .	16.7–25.3	0.770	7	Parallel to longi-			
Ebonite . . .	25.3–35.4	0.842	7	tudinal axis	"	0.0937	8
Fluor spar: CaF_2 .	0–100	0.1950	8	Parallel to hori-			
German silver . .	"	0.1836	8	zontal axis	"	0.0773	8
Gold-platinum:				Type metal . .	16.6–254	0.1952	5
2Au+1Pt	"	0.1523	4	Vulcanite . .	0–18	0.6360	18
Gold-copper:				Wedgwood ware .	0–100	0.0890	5
2Au+1Cu	"	0.1552	4	Wood:			
Glass:				Parallel to fibre:			
Tube . . .	"	0.0833	1	Ash . . .	"	0.0951	19
" . . .	"	0.0828	9	Beech . .	2–34	0.0257	20
Plate . . .	"	0.0891	10	Chestnut . .	"	0.0649	20
Crown (mean) .	"	0.0897	10	Elm . . .	"	0.0565	20
" .	50–60	0.0954	11	Mahogany .	"	0.0361	20
Flint . . .	"	0.0788	11	Maple . .	"	0.0638	20
Jena thermometer				Oak . . .	"	0.0492	20
(normal)	0–100	0.081	12	Pine . . .	"	0.0541	20
" " 59^{III}	"	0.058	12	Walnut . .	"	0.0658	20
Gutta percha . .	20	1.983	13	Across the fibre:			
Ice	-20 to -1	0.375	14	Beech . .	"	0.614	20
Iceland spar: .				Chestnut . .	"	0.325	20
Parallel to axis .	0–80	0.2631	6	Elm . . .	"	0.443	20
Perpendicular to				Mahogany .	"	0.404	20
axis	"	0.0544	6	Maple . .	"	0.484	20
Lead-tin (solder)				Oak . . .	"	0.544	20
2Pb+1Sn	0–100	0.2508	1	Pine . . .	"	0.341	20
Paraffin . . .	0–16	1.0662	15	Walnut . .	"	0.484	20
" . . .	16–38	1.3030	15	Wax: White . .	10–26	2.300	21
" . . .	38–49	4.7707	15	" . .	26–31	3.120	21
Platinum-iridium				" . .	31–43	4.860	21
10Pt+1Ir	40	0.0884	3	" . .	43–57	15.227	21

AUTHORITIES.

1 Smeaton.
2 Various.
3 Fizeau.
4 Matthieson.
5 Daniell.
6 Benoit.
7 Kohlrausch.
8 Pfaff.
9 Deluc.
10 Lavoisier and Laplace.
11 Pulfrich.
12 Schott.
13 Russner.
14 Brunner.
15 Rodwell.
16 Braun.
17 Deville and Troost.
18 Mayer.
19 Glatzel.
20 Villari.
21 Kopp.

TABLE 223.

COEFFICIENTS OF THERMAL EXPANSION.

Coefficients of Cubical Expansion of some Crystalline and other Solids.*

T = temperature or range of temperature, C = coefficient of cubical expansion, A = authority.

Substance.	T	$C \times 10^4$	A
Antimony	0–100	0.3167	Matthieson.
Beryl	0–100	0.0105	Pfaff.
Bismuth	–	0.4000	Kopp.
Diamond	40	0.0354	Fizeau.
Emerald	40	0.0168	"
Fluor spar	14–47	0.6235	Kopp.
Garnet	0–100	0.2543	Pfaff.
Glass, white tube	0–100	0.2648	Regnault.
" green tube	0–100	0.2299	"
" Swedish tube	0–100	0.2363	"
" hard French tube	0–100	0.2142	"
" crystal tube	0–100	0.2101	"
" common tube	0–1	0.2579	"
" Jena	0–100	0.2533	Reichsanstalt.
Ice	—20 to —1	1.1250	Brunner.
Iceland spar	50–60	0.1447	Pulfrich.
Idocrase	0–100	0.2700	Pfaff.
Iron	0–100	0.3550	Dulong and Petit.
"	0–300	0.4410	" " "
Magnetite, Fe_3O_4	0–100	0.2862	Pfaff.
Manganic oxide, Mn_2O_3	0–100	0.522	Playfair and Joule.
Orthoclase (adularia)	0–100	0.1794	Pfaff.
Porcelain	0–100	0.1080	Deville and Troost.
Quartz	50–60	0.3530	Pulfrich.
Rock salt	50–60	1.2120	"
Spinel ruby	40	0.1787	Fizeau.
Sulphur, rhombic	0–100	2.2373	Kopp.
Topaz	0–100	0.2137	Pfaff.
Tourmaline	0–100	0.2181	"
Zincite, ZnO	40	0.0279	Fizeau.
Zircon	0–100	0.2835	Pfaff.

* For more complete tables of cubical expansion, see Clarke's "Constants of Nature," (Smithsonian Collections), published in 1876.

COEFFICIENTS OF THERMAL EXPANSION.

Coefficients of Cubical Expansion of Liquids.

This table contains the coefficients of expansion of some liquids and solutions of salts. When not otherwise stated atmospheric pressure is to be understood. T gives the temperature range, C the mean coefficient of expansion for range T in degrees C., and A_1 the authority for C. α, β, and γ are the coefficients in the volume equation $v_t = v_0(1 + \alpha t + \beta t^2 + \gamma t^3)$, and m the mean coefficient for range 0°–100° C., and A_2 is the authority for these.

Liquid.	T	$C \times 1000$	A_1	$m \times 100$	$\alpha \times 1000$	$\beta \times 10^6$	$\gamma \times 10^8$	A_2
Acetic acid	16°–107°	–	–	.1433	1.0630	0.1264	1.0876	3
Acetone	0–54	–	–	.1616	1.3240	3.8090	0.8798	3
Alcohol:								
Amyl	−15 to +80	–	–	–	0.8900	0.6573	1.1846	4
Ethyl, sp. gr. .8095	0–80	–	–	–	1.0414	0.7836	1.7168	5
" 50 % by volume	0–39	–	–	–	0.7450	1.850	0.730	6
" 30 % "	18–39	–	–	–	0.2928	17.900	11.87	6
" 500 atmo. press.	0–40	.866	1	–	–	–	–	–
" 3000 " "	0–40	.524	1	–	–	–	–	–
Methyl	−38 to +70	–	–	.1433	1.1856	1.5649	0.9111	4
Benzene	11–81	–	–	.1385	1.1763	1.2775	0.8065	5
Bromine	−7 to +60	–	–	.1168	1.0382	1.7114	0.5447	4
Calcium chloride:								
$CaCl_2$, 5.8 % solution	18–25	–	–	.0506	0.0788	4.2742	–	7
$CaCl_2$, 40.9 % "	17–24	–	–	.0510	0.4238	0.8571	–	7
Carbon disulphide	−34 to +60	–	–	.1468	1.1398	1.3706	1.9122	4
500 atmos. pressure	0–50	.940	1	–	–	–	–	–
3000 " "	0–50	.581	1	–	–	–	–	–
Chloroform	0–63	–	–	.1399	1.1071	4.6647	1.7433	4
Ether	−15 to +38	–	–	.2150	1.5132	2.3592	4.0051	4
Glycerine	–	–	–	.0534	0.4853	0.4895	–	8
Hydrochloric acid:								
$HCl + 6.25H_2O$	0–30	–	–	.0489	0.4460	0.430	–	9
$HCl + 50H_2O$	0–30	–	–	.0933	0.0625	8.710	–	9
Mercury	24–299	–	–	–	0.1818	0.000175	0.003512	10
Olive oil	–	–	–	.0742	0.6821	1.1405	−.539	11
Potassium chloride:								
KCl, 2.5 % solution	–	–	–	.0572	–	–	–	7
KCl, 24.3 % "	–	–	–	.0477	–	–	–	7
Potassium nitrate:								
KNO_3, 5.3 % sol'n	–	–	–	.0539	–	–	–	12
KNO_3, 21.9 % "	–	–	–	.0577	–	–	–	12
Phenol, C_6H_6O	36–157	–	–	.0899	0.8340	0.1073	0.4446	13
Petroleum	7–38	.992	2	–	–	–	–	–
Sp. gr. 0.8467	24–120	–	–	.1039	0.8994	1.396	–	14
Sodium chloride:								
NaCl, 1.6 % solution	–	–	–	.1067	0.0213	10.462	–	9
Sodium sulphate:								
Na_2SO_4, 24 % sol'n	10–40	–	–	.0611	0.3599	2.516	–	9
Sodium nitrate:								
$NaNO_3$, 36.2 % sol'n	20–78	–	–	.0627	0.5408	1.075	–	12
Sulphuric acid:								
H_2SO_4	0–30	–	–	.0489	0.5758	0.864	–	9
$H_2SO_4 + 50H_2O$	0–30	–	–	.0799	0.2835	5.160	–	9
Turpentine	−9 to +106	–	–	.1051	0.9003	1.959	–	5
Water	0–200	–	–	–	−.0658	8.507	−6.769	15

AUTHORITIES.

1 Amagat.
2 Barrett.
3 Zander.
4 Pierre.
5 Kopp.
6 Recknagel.
7 Decker.
8 Emo.
9 Marignac.
10 Broch.
11 Spring.
12 Nicol.
13 Pinette.
14 Frankenheim.
15 Scheel.

TABLE 225.

COEFFICIENTS OF THERMAL EXPANSION.

Coefficients of Expansion of Gases.

The numbers obtained by direct experiment on the change of volume at constant pressure, E_p, are separated in the table from those obtained from the change of pressure at constant volume, E_v. The two parts of the table are headed "Coefficient at constant pressure" and "Coefficient at constant volume," respectively. Ordinary changes of atmospheric pressure produce very little change in the coefficient of expansion, and hence entries in the pressure column of 1 atm. have been made for all pressures near to 76 centimetres of mercury. The other numbers in the pressure columns are centimetres of mercury at 0° C. and approx. 45° latitude, unless otherwise marked.

Thomson has given (*vide* Encyc. Brit. art. "Heat") the following equations for the calculation of the expansion, E, between 0° and 100° C. of the gases named. Expansion is to be understood as change of volume under constant pressure.

$$\text{Hydrogen} \quad E = .3662\left(1 - .00049\,\frac{V_0}{v_0}\right)$$

$$\text{Common air} \quad E = .3662\left(1 + .0026\,\frac{V_0}{v_0}\right)$$

$$\text{Oxygen} \quad E = .3662\left(1 + .0032\,\frac{V_0}{v_0}\right)$$

$$\text{Nitrogen} \quad E = .3662\left(1 + .0031\,\frac{V_0}{v_0}\right)$$

$$\text{Carbon dioxide} \quad E = .3662\left(1 + .0164\,\frac{V_0}{v_0}\right)$$

where V_0 / v_0 is the ratio of the actual density of the gas at 0° C. to the density it would have at 0° C. and one atmosphere of pressure. The same experiments (Thomson & Joule, Trans. Roy. Soc. 1860), — which, together with Regnault's data, led to these equations, — give for the absolute temperature of melting ice 2.731 times the temperature interval between the melting-point of ice and the boiling-point of water under normal atmospheric pressure.

Coefficient at constant volume.

Substance.	Pressure.	$E_v \times 100$	Authority.
Air	0.6	.3765	1
"	1.6	.3703	1
"	7.6	.3665	1
"	10.0	.3663	1
"	26.0	.3660	1
"	37.6	.3662	1
"	75.0	.3665	1
"	76–83	.3670	2*
"	11–15	.3648	3
"	17–24	.3651	3
"	37–51	.3658	3
"	76	.3665	3
"	200	.3690	3
"	2000	.3887	3
"	10000	.4100	3
"	76	.3669	3*
"	76	.3671	4
"	1 atm.	.3670	5*
Carbon dioxide	1 "	.3706	5
" "	1 "	.3726	1
" "	76–104	.3686	3
" "	174–234	.3752	3
" "	793	.4252	3
" " 0°–64°	16.4 atm.	.4754	6
" " 64°–100°	16.4 "	.4607	6
" " 0°–64°	25.87 "	.5728	6
" " 64°–100°	25.87 "	.5406	6
" " 0°–64°	33.53 "	.6973	6
" " 64°–100°	33.53 "	.6334	6
Carbon monoxide	1 "	.3667	3
Hydrogen	1 "	.3669	3
"	1 "	.3656	5
Nitrogen	1 "	.3668	3
Nitrous oxide	1 "	.3676	3
" "	1 "	.3707	5
Oxygen	1 "	.3674	5
Sulphur dioxide, SO_2	1 "	.3845	5

Coefficient at constant pressure.†

Substance.	Pressure.	$E_p \times 100.$	Authority.
Air	76.	0.3671	3
"	257.	0.3695	3
Hydrogen	76.	0.36613	3
"	254.	0.36616	3
Carbon dioxide	76.	0.3710	3
" "	252.	0.3845	3
" " 0°–64°	17.1 atm.	0.5136	6
" " 64°–100°	17.1 "	0.4747	6
" " 0°–7.5°	24.81 "	0.7000	6
" " 0°–64°	24.81 "	0.6204	6
" " 64°–100°	24.81 "	0.5435	6
" " 0°–7.5°	34.49 "	1.0970	6
" " 0°–64°	34.49 "	0.8450	6
" " 0°–100°	34.49 "	0.6574	6
Carbon monoxide	76.	0.3669	3
Nitrous oxide	76.	0.3719	3
Sulphur dioxide	76.	0.3903	3
" "	98.	0.3980	3
Water vapor, 0°–119°	1 atm.	0.4187	7
" " 0°–141°	1 "	0.4189	7
" " 0°–162°	1 "	0.4071	7
" " 0°–200°	1 "	0.3938	7
" " 0°–247°	1 "	0.3799	7

AUTHORITIES.

1 Melander.
2 Magnus.
3 Regnault.
4 Rowland.
5 Jolly.
6 Andrews.
7 Hirn.

* Corrected by Mendelejeff to 45° latitude and absolute expansion of mercury. Rowland gets almost the same correction on Regnault, using Wüllner's value of the expansion of mercury.

† The series of results at different pressures are given because of their interest. The absolute values are a little too low. (See preceding footnote.)

DYNAMICAL EQUIVALENT OF THE THERMAL UNIT.

Rowland in his paper quoted in Table 227 has given an elaborate discussion of Joule's determinations and the corrections required to reduce them to temperatures as measured by the air thermometer. The following table contains the results obtained, together with the corresponding results obtained in Rowland's own experiments. The variation for change of temperature in Rowland's result is due to the variation with temperature of the specific heat of water.

Date.	Method of experiment.	Temp. of water C.°	Joule's value.	Joule's value reduced to air thermometer and latitude of Baltimore. Eng. units.	Met. units.	Rowland's value.	J—R.	Relative weight of Joule's value as estimated by Rowland.
1847	Friction of water .	15	781.5	787.0	442.8	427.4	+15.4	0
1850	" " " .	14	772.7	778.0	426.8	427.7	—0.9	10
1850	" " mercury	9	772.8	779.2	427.5	428.8	—1.3	2
1850	" " "	9	775.4	781.4	428.7	428.8	—0.1	2
1850	" " iron .	9	776.0	782.2	429.1	428.8	+0.3	1
1850	" " " .	9	773.9	780.2	428.0	428.8	—0.8	1
1867	Electric heating . .	18.6	-	-	428.0	426.7	+1.3	3
1878	Friction of water .	14.7	772.7	776.1	425.8	427.6	—1.8	2
1878	" " " .	12.7	774.6	778.5	427.1	428.0	—0.9	3
1878	" " " .	15.5	773.1	776.4	426.0	427.3	—1.3	5
1878	" " " .	14.5	767.0	770.5	422.7	427.5	—4.8	1
1878	" " " .	17.3	774.0	777.0	426.3	426.9	—0.6	1

From the above values and weights Rowland concludes as the most probable value from Joule's experiments, at the temperature 14.6° C. and the latitude of Baltimore, 426.75, and from his own experiments 427.52.

The mean of these results is 427.13 in metric units, or 778.6 in British units. Correcting back for latitude, and to mercury thermometer, this gives about 774.5 for the latitude of Manchester, instead of 772, as has been commonly used.

An elaborate determination recently made by Griffith and referred to in Table 227 gives a value about one tenth of one per cent higher than Rowland's. Probably when a mercury thermometer is involved in the measurements we may take 776 as the nearest whole number in foot-pounds and British thermal units for the latitude of Manchester, and 777 for that of Baltimore. The corresponding values in the metric system will be 425.8 and 426.3, or in round numbers 426 for both latitudes.

The following quantities should be added to the equivalent of Baltimore to give the equivalent at the latitude named: —

Latitude	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
Kilogramme-metres	0.89	0.82	0.63	0.34	0.08	—0.41	—0.77	—1.06	—1.26	—1.33
Foot-pounds . . .	1.62	1.50	1.15	0.62	0.15	—0.75	—1.41	—1.93	—2.30	—2.43

TABLE 227.

MECHANICAL EQUIVALENT OF HEAT.

The following historical table of the principal experimental determinations of the mechanical equivalent of the unit of heat has been, with the exception of the few determinations bearing dates later than 1879, taken from Rowland.* The different determinations are divided into four groups, according to the method used. Calculations based on the constants of gases and vapors as determined by others are not included in this table.

Method.	Observer.	Date.	Result.
Compression of air	Joule[1]	1845	443.8
Expansion " "	Joule[1]	1845	437.8
Experiments on steam engine	Hirn[2]	1857	413.0
" " " "	Hirn[2]	1860–1	420–432
Expansion and contraction of metals	Edlund[3]	1865	443.6 430.1 428.3
" " " " "	Haga[4]	1881	437.8 428.1
Measurement of the specific volume of vapor	Perot[5]	1886	424.3
Boring of cannon	Rumford[6]	1798	940 ft.-lbs.
Friction of water in tubes	Joule[7]	1843	424.6
" " " " calorimeter	Joule[1]	1845	488.3
" " " " "	Joule[8]	1847	428.9
" " " " "	Joule[9]	1850	423.9
" " mercury in "	Joule[9]	1850	424.7
" " plates of iron	Joule[9]	1850	425.2
" " metals	Hirn[2]	1857	371.6
" " " in mercury calorimeter	Favre[10]	1858	413.2
" " "	Hirn[2]	1858	400–450
Boring " "	Hirn[2]	1858	425.0
Water in *balance à frottement*	Hirn[2]	1860–1	432.0
Flow of liquids under strong pressure	Hirn[2]	1860–1	432.0
Crushing of lead	Hirn[2]	1860–1	425.0
Friction of metals	Puluj[11]	1876	426.6
Friction of water in calorimeter	Joule[12]	1878	423.9
" " " " "	Rowland[13]	1879	426.3
" " metals	Sahulka[14]	1890	427.5
Heating by magneto-electric currents	Joule[7]	1843	460.0
Heat generated in a disc between the poles of a magnet	Violle[15]	1870	435.2 434.9 435.8 437.4
Flow of mercury under pressure	Bartoli[16]	1880	428.4
Heat developed in wire of known absolute resistance	Quintus Icilius,[17] also Weber	1857	399.7
Heat developed in wire of known absolute resistance	Lenz Weber	1859	396.4 478.2
Heat developed in wire of known absolute resistance	Joule[18]	1867	429.5
Heat developed in wire of known absolute resistance	H. F. Weber[19]	1877	428.15
Heat developed in wire of known absolute resistance	Webster[20]	1885	414×10^5 ergs per gramme degree.
Heat developed in wire of known absolute resistance	Dieterici[21]	1888	424.36

REFERENCES.

See opposite page.

* "Proc. Am. Acad. Arts and Sci." vol. 15.

MECHANICAL EQUIVALENT OF HEAT.

Method.	Observer.	Date.	Result.
Diminishing the heat contained in a battery when the current produces work . . .	Joule [7]	1843	499.0
Diminishing the heat contained in a battery when the current produces work . . .	Favre [22]	1858	443.0
Heat due to electrical current, electro-chemical equivalent of water = .009379, absolute resistance, electro-motive force of Daniell cell, heat developed by action of zinc on sulphate of copper	Weber, Boscha, Favre, and Silbermann	1857	432.1
Heat developed in Daniell cell . . . . Electromotive force of Daniell cell . . .	Joule Boscha [23]	1859	419.5
Combination of electrical heating and mechanical action by stirring water	Griffiths [24]	1893	428.0

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1 Joule, "Phil. Mag." (3) vol. 26.
2 Hirn, "Théorie Méc. de la Chaleur," sér. 1, 3me éd.
3 Edlund, "Pogg. Ann." vol. 114.
4 Haga, "Wied. Ann." vol. 15.
5 Perot, "Compt. Rend." vol. 102.
6 Rumford, "Phil. Trans. Roy. Soc." 1798; Favre, "Compt. Rend." 1858.
7 Joule, "Phil. Mag." (3) vol. 23.
8 Joule, " " " " 27.
9 Joule, " " " " 31.
10 Favre, "Compt. Rend." 1858; "Phil. Mag." (4) vol. 15.
11 Puluj, "Pogg. Ann." vol. 157.
12 Joule, "Proc. Roy. Soc." vol. 27.
13 Rowland, "Proc. Am. Acad. Arts & Sci." vols. 15 & 16.
14 Sahulka, "Wied. Ann." vol. 41.
15 Violle, "Ann. de Chim." (4) vol. 22.
16 Bartoli, "Mem. Acc. Lincei," (3) vol. 8.
17 Quintus Icilius, "Pogg. Ann." vol. 101.
18 Joule, "Rep. Com. on Elec. Stand.," "B. A. Proc." 1867.
19 H. F. Weber, "Phil. Mag." (5) vol. 5.
20 Webster, "Proc. Am. Acad. Arts & Sci." vol. 20.
21 Dieterici, "Wied. Ann." vol. 33.
22 Favre, "Compt. Rend." vol. 47.
23 Boscha, "Pogg. Ann." vol. 108.
24 Griffiths, "Phil. Trans. Roy. Soc." 1893.

SPECIFIC HEAT.

Specific Heat of Water.

The specific heat of water is a matter of considerable importance in many physical measurements, and it has been the subject of a number of experimental investigations, which unfortunately have led to very discordant results. Regnault's measurements, published in 1847,* show an increase of specific heat with rise of temperature. His results are approximately expressed by the equation

$$c = 1 + .0004\,t + 0000009\,t^2,$$

which makes the specific heat nearly constant within the atmospheric range. A different equation was found from Regnault's results by Boscha, who thought the temperatures required correction to the air-thermometer. Regnault, however, pointed out that the results had already been corrected. Jamin and Amaury † found, for a range from 9° to 76° C., the equation

$$c = 1 + .0011\,t + .0000012\,t^2,$$

which nearly all the evidence available shows to be very much too rapid a change. Wüllner gives, for some experiments of Münchhausen,‡ the equation

$$c = 1 + .000301102\,t$$

in vol. 1, changed to

$$c = 1 + .000425\,t$$

in vol. 10, for a range of temperature from 17° to 64°. In 1879, experiments are recorded by Stamo,§ by Henrichsen,‖ and by Baumgarten,‖ all of them giving large variation with temperature.

In 1879, Rowland inferred from his experiments on the mechanical equivalent of heat that the specific heat of water really passes through a minimum at about 30°, and he attempted to verify this by direct experiment. The results obtained by direct experiments were not by any means so satisfactory as those obtained from the friction experiment; but they also indicated that the specific heat passed through a minimum, — but, in this case, at about 20° C. Further, direct experiments were made in 1883, in Rowland's laboratory, by Liebig, using the same calorimetric apparatus; and these experiments also show a minimum at about 20° C.¶ Since the publication of Rowland's paper a number of new determinations have been made. Gerosa gave, in 1881, a series of equations which show a maximum at 4°.4, then a minimum a little above 5° and afterwards a rise to 24°! Neesen ** found a minimum near 30°, but got rather less variation than Rowland. Rapp,†† taking the mean specific heat between 0° and 100° as unity, gives the equation

$$c = 1.039925 - .007068\,t + .00021255\,t^2 - .000001584\,t^3,$$

which gives a minimum between 20° and 30° and a maximum about 70°. Volten ‡‡ gives an equation which is even more extraordinary with regard to coefficients than the last, namely,

$$c = 1 - .0014625512\,t + .0000237981\,t^2 - .00000010716\,t^3,$$

which puts the minimum between 40° and 50°, and gives a maximum at 100°; which maximum is, however, less than unity. Dieterici, in his paper on the mechanical equivalent of heat, discusses this subject; but his own results being in close agreement with Rowland's, his table practically only extends Rowland's results through a greater range of temperature, assuming straight-line variation to the two sides of the minimum. Bartoli and Stracciati §§ found a minimum at about 30°; while Johanson in the same year gives a minimum at about 4° and then a rise about 12 times as rapid as that of Regnault. Griffiths ‖‖ finds the equation

$$c = 1 - .0002666\,(t - 15)$$

to satisfy his experiments through the range from 15° to 26°. This agrees fairly well with Rowland through the same range, and indicates that the minimum is at a temperature higher than 26°.

The following table gives the results of Rowland, Bartoli and Stracciati, and Griffiths. The column headed "Rowland" has been calculated from Rowland's values of the mechanical equivalent of heat at different temperatures, on the assumption that the specific heat at 15° is equal to unity.

* "Mém. de l'Acad." vol. 21.
† "Compt. Rend." vol. 70, 1870.
‡ "Wied. Ann." vols. 1 and 10.
§ "Wied. Beib." vol. 3.
‖ "Wied. Ann." vol. 8.
¶ Rowland, "Proc. Am. Acad." vol. 15, and Liebig, "Am. Jour. of Sci." vol. 26.
** "Wied. Ann." vol. 18, 1883.
†† "Diss. Zürich."
‡‡ "Wied. Ann." vol. 21, 1884.
§§ "Wied. Beib." vol. 15, 1891.
‖‖ "Phil. Trans." 1893.

SPECIFIC HEAT.

TABLE 228. — Specific Heat of Water.

Temp. C.	Rowland.	Bartoli and Stracciati.	Griffiths.	Temp. C.	Rowland.	Bartoli and Stracciati.	Griffiths.	Dieterici. Temp. C.	Dieterici. Specific heat.
0°	1.0075*	1.0066	-	19°	0.9984	0.9995	0.9989	0°	1.0000
1	1.0070*	1.0060	-	20	0.9980	0.9995	0.9987	10	0.9943
2	1.0065*	1.0054	-	21	0.9976	0.9995	0.9984	20	0.9893
3	1.0060*	1.0049	-	22	0.9973	0.9996	0.9981	30	0.9872
4	1.0055*	1.0043	-	23	0.9971	0.9996	0.9979	40	0.9934
5	1.0050	1.0038	-	24	0.9968	0.9998	0.9976	50	0.9995
6	1.0045	1.0033	-	25	0.9967	1.0001	0.9973	60	1.0057
7	1.0040	1.0028	-	26	0.9965	1.0003	0.9971	70	1.0120
8	1.0034	1.0023	-	27	0.9964	1.0006	0.9967	80	1.0182
9	1.0029	1.0019	-	28	0.9963	1.0010	-	90	1.0244
10	1.0024	1.0015	-	29	0.9962	1.0014	-	100	1.0306
11	1.0019	1.0011	-	30	0.9962	1.0019	-	-	-
12	1.0014	1.0008	-	31	0.9963	1.0024	-	-	-
13	1.0009	1.0005	-	32	0.9963	-	-	-	-
14	1.0005	1.0002	-	33	0.9964	-	-	-	-
15	1.0000	1.0000	1.0000	34	0.9965	-	-	-	-
16	0.9996	0.9998	0.9997	35	0.9966	-	-	-	-
17	0.9991	0.9997	0.9995	36	0.9967	-	-	-	-
18	0.9987	0.9996	0.9992						

TABLE 229. — Specific Heat of Air.

The ratio of the specific heat at constant pressure to the specific heat at constant volume has been the subject of much investigation, and more particularly so in the case of atmospheric air, on account of its interest in connection with the velocity of sound. The following table gives the results of the principal direct determinations of this ratio for air. It may be remarked that the methods most commonly employed have been modifications of that employed by Clement and Desormes, and that the chances of error towards too small a ratio by this method are considerable.

Date.	Ratio.	Experimenters.
1812	1.354	Clement and Desormes.
-	1.374	Gay Lussac and Welter.
-	1.249	Delaroche and Berard.
1853	1.421	Favre and Silbermann.
1858	1.4196	Masson.
1859	1.4025	Weisbach.
1861	1.3845	Hirn.
1862	1.41	Cazin.
1863	1.399	Dupré.
1864	1.41	Jamin and Richards.
1864	1.399	Tresca and Laboulaye.
1869	1.302	Kohlrausch.
1873	1.4053	Röntgen.
1874	1.397	Amagat.
1883	1.4062	Müller.
1887	1.384	Lummer.

Some of these results are clearly too low; and hence neglecting all those that fall below 1.39 and giving equal weights to the remainder we obtain, with a somewhat large probable error, the value 1.4070.

The values obtained indirectly from the velocity of sound are undoubtedly much more accurate, judged either by the greater ease of the experiment or by the better agreement of the results. Assuming that the value 332 metres per second is good for the velocity of sound, the ratio of the specific heats must be near to 1.4063. Probably 1.4065 may be taken as fairly representing present knowledge of the subject.

* Variation assumed uniform below 7 with same slope as from 7 to 5.

NOTE. — For specific heats of metals, solids and liquids, see pp. 294 to 296.

SPECIFIC HEAT.

Specific Heat of Gases and Vapors.

Substance.	Range of temp. C.°	Sp. ht. pressure constant.	Authority.	Mean ratio of sp. hts.	Authority.	Calculated sp. ht. vol. const.
Acetone	26–110	0.3468	Wiedemann	–	–	
"	27–179	0.3740	"	–	–	
"	129–233	0.4125	Regnault	–	–	
Air	−30 to +10	0.23771	"	–	–	
"	0–100	0.23741	"	–	–	
"	0–200	0.23751	"	–	–	
"	20–100	0.2389	Wiedemann	–	–	
"	mean	**0.23788**	–	1.4066	Various	0.1691
Alcohol, ethyl	108–220	0.4534	Regnault	1.136	Jaeger, Neyreneuf	0.3991
" methyl	101–223	0.4580	"	–	–	
Ammonia	23–100	0.5202	Wiedemann	–	–	
"	27–200	0.5356	"	–	–	
"	24–216	0.5125	Regnault	–	–	
"	mean	**0.5228**	–	1.31	Cazin, Wüllner	0.3991
Benzene	34–115	0.2990	Wiedemann	–	–	
"	35–180	0.3325	"	–	–	
"	116–218	0.3754	Regnault	–	–	
Bromine	83–228	0.0555	"	–	–	
"	19–388	0.0553	Strecker	1.293	Strecker	0.0428
Carbon dioxide	−28 to +7	0.1843	Regnault	–	–	
" "	15–100	0.2025	"	–	–	
" "	11–214	0.2169	"	–	–	
" "	mean	**0.2012**	–	1.300	Röntgen, Wüllner	0.1548
Carbon monoxide	23–99	0.2425	Wiedemann	–	–	
" "	26–198	0.2426	"	1.403	Cazin, Wüllner	0.1729
Carbon disulphide	86–190	0.1596	Regnault	1.200	Beyne	0.1330
Chlorine	13–202	0.1210	"	–	–	
"	16–343	0.1125	Strecker	1.323	Strecker	0.0850
Chloroform	27–118	0.1441	Wiedemann	–	–	
"	28–189	0.1489	"	1.106	Beyme, Müller	0.1346
Ether	69–224	0.4797	Regnault	–	–	
"	27–189	0.4618	Wiedemann	–	–	
"	25–111	0.4280	"	–	–	
"	mean	**0.4565**	–	1.029	Müller	0.4436
Hydrochloric acid	22–214	0.1852	Regnault	–	–	
" "	13–100	0.1940	Strecker	1.395	Strecker	0.1391
Hydrogen	−28 to +9	3.3996	Regnault	–	–	
"	12–198	3.4090	"	–	–	
"	21–100	3.4100	Wiedemann	–	–	
"	mean	**3.4062**	–	1.410	Cazin	2.419
" sulphide (H_2S)	20–206	0.2451	Regnault	1.276	Müller	0.1925
Methane	18–208	0.5929	"	1.316	"	0.4505
Nitrogen	0–200	0.2438	"	1.410	Cazin	0.1729
Nitric oxide (NO)	13–172	0.2317	"	–	–	
Nitrogen tetroxide (NO_2)	27–67	1.625	Berthelot and Ogier	–	–	
" " "	27–150	1.115	"	–	–	
" " "	27–280	0.650	"	–	–	
Nitrous oxide	16–207	0.2262	Regnault	–	–	
" "	26–103	0.2126	Wiedemann	–	–	
" "	27–206	0.2241	"	–	–	
" "	mean	**0.2214**	–	1.291	Wüllner	.1715
Sulphur dioxide (SO_2)	16–202	0.1544	Regnault	1.26	Cazin, Müller	0.1225
Water	128–217	0.4805	"	–	–	
"	100–125	0.3787	Macfarlane Gray	–	–	
"	mean	**0.4296**	–	1.300	Various	0.3305

VAPOR PRESSURE.

TABLE 231. — Vapor Pressure of Ethyl Alcohol.*

Temp. C.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
	Vapor pressure in millimetres of mercury at 0° C.									
0°	12.24	13.18	14.15	15.16	16.21	17.31	18.46	19.68	20.98	22.34
10	23.78	25.31	27.94	28.67	30.50	32.44	34.49	36.67	38.97	41.40
20	44.00	46.66	49.47	52.44	55.56	58.86	62.33	65.97	69.80	73.83
30	78.06	82.50	87.17	92.07	97.21	102.60	108.24	114.15	120.35	126.86
40	133.70	140.75	148.10	155.80	163.80	172.20	181.00	190.10	199.65	209.60
50	220.00	230.80	242.50	253.80	265.90	278.60	291.85	305.65	319.95	334.85
60	350.30	366.40	383.10	400.40	418.35	437.00	456.35	476.45	497.25	518.85
70	541.20	564.35	588.35	613.20	638.95	665.55	693.10	721.55	751.00	781.45

From the formula $\log p = a + b\alpha^t + c\beta^t$ Ramsay and Young obtain the following numbers.†

Temp. C.	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
	Vapor pressure in millimetres of mercury at 0° C.									
0°	12.24	23.73	43.97	78.11	133.42	219.82	350.21	540.91	811.81	1186.5
100	1692.3	2359.8	3223.0	4318.7	5686.6	7368.7	9409.9	11858.	14764.	18185.
200	22182.	26825.	32196.	38389.	45519.					

TABLE 232. — Vapor Pressure of Methyl Alcohol.‡

Temp. C.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
	Vapor pressure in millimetres of mercury at 0° C.									
0°	29.97	31.6	33.6	35.6	37.8	40.2	42.6	45.2	47.9	50.8
10	53.8	57.0	60.3	63.8	67.5	71.4	75.5	79.8	84.3	89.0
20	94.0	99.2	104.7	110.4	116.5	122.7	129.3	136.2	143.4	151.0
30	158.9	167.1	175.7	184.7	194.1	203.9	214.1	224.7	235.8	247.4
40	259.4	271.9	285.0	298.5	312.6	327.3	342.5	358.3	374.7	391.7
50	409.4	427.7	446.6	466.3	486.6	507.7	529.5	552.0	575.3	599.4
60	624.3	650.0	676.5	703.8	732.0	761.1	791.1	822.0	–	–

* This table has been compiled from results published by Ramsay and Young (Jour. Chem. Soc. vol. 47, and Phil. Trans. Roy. Soc., 1886).

† In this formula $a = 5.0720301$; $\log b = \bar{2}.6406131$; $\log c = 0.6050854$; $\log \alpha = 0.003377538$; $\log \beta = \bar{1}.99682424$ (c is negative).

‡ Taken from a paper by Dittmar and Fawsitt (Trans. Roy. Soc. Edin. vol. 33).

TABLE 233.

VAPOR PRESSURE.*

Carbon Disulphide, Chlorobenzene, Bromobenzene, and Aniline.

Temp.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
					(a) CARBON DISULPHIDE.					
0°	127.90	133.85	140.05	146.45	153.10	160.00	167.15	174.60	182.25	190.20
10	198.45	207.00	215.80	224.95	234.40	244.15	254 25	264.65	275.40	286.55
20	298.05	309.90	322.10	334.70	347.70	361.10	374.95	389.20	403.90	419.00
30	434.60	450.65	467.15	484.15	501.65	519.65	538.15	557.15	576.75	596.85
40	617.50	638.70	660.50	682.90	705.90	729.50	753.75	778.60	804.10	830.25
					(b) CHLOROBENZENE.					
20°	8.65	9.14	9.66	10.21	10.79	11.40	12.04	12.71	13.42	14.17
30	14.95	15.77	16.63	17.53	18.47	19.45	20.48	21.56	22.69	23.87
40	25.10	26.38	27.72	29.12	30.58	32.10	33.69	35.35	37.08	38.88
50	40.75	42.69	44.72	46.84	49.05	51.35	53.74	56.22	58.79	61.45
60	64.20	67.06	70.03	73.11	76.30	79.60	83.02	86.56	90.22	94.00
70	97.90	101.95	106.10	110.41	114.85	119.45	124.20	129.10	134.15	139.40
80	144.80	150.30	156.05	161.95	168.00	174.25	181.70	187.30	194.10	201.15
90	208.35	215.80	223.45	231.30	239.35	247.70	256.20	265.00	274.00	283.25
100	292.75	302.50	312.50	322.80	333.35	344.15	355.25	366.65	378.30	390.25
110	402.55	415.10	427.95	441.15	454.65	468.50	482.65	497.20	512.05	527.25
120	542.80	558.70	575.05	591.70	608.75	626.15	643.95	662.15	680.75	699.65
130	718.95	738.65	758.80	–	–	–	–	–	–	–
					(c) BROMOBENZENE.					
40°	–	–	–	–	–	12.40	13.06	13.75	14.47	15.22
50	16.00	16.82	17.68	18.58	19.52	20.50	21.52	22.59	23.71	24.88
60	26.10	27.36	28.68	30.06	31.50	33.00	34.56	36.18	37.86	39.60
70	41.40	43.28	45.24	47.28	49.40	51.60	53.88	56.25	58.71	61.26
80	63.90	66.64	69.48	72 42	75.46	78.60	81.84	85.20	88.68	92.28
90	96.00	99.84	103.80	107.88	112.08	116.40	120.86	125.46	130.20	135.08
100	140.10	145.26	150.57	156.03	161.64	167.40	173.32	179.41	185.67	192.10
110	198.70	205.48	212.44	219 58	226.90	234.40	242.10	250.00	258.10	266.40
120	274.90	283.65	292.60	301.75	311.15	320.80	330.70	340.80	351.15	361.80
130	372.65	383.75	395.10	406.70	418.60	430.75	443.20	455.90	468.90	482.20
140	495.80	509.70	523.90	538.40	553.20	568.35	583.85	599.65	615.75	632.25
150	649.05	666.25	683.80	701.65	719.95	738.55	757.55	776.95	796.70	816.90
					(d) ANILINE.					
80°	18.80	19.78	20.79	21.83	22.90	24.00	25.14	26.32	27.54	28.80
90	30.10	31.44	32.83	34.27	35.76	37.30	38.90	40.56	42.28	44.06
100	45.90	47.80	49.78	51.84	53.98	56.20	58.50	60.88	63.34	65.88
110	68.50	71.22	74.04	76.96	79.98	83.10	86.32	89.66	93.12	96.70
120	100.40	104.22	108.17	112.25	116.46	120.80	125.28	129.91	134.69	139.62
130	144.70	149.94	155.34	160.90	166.62	172.50	178.56	184 80	191.22	197.82
140	204.60	211.58	218.76	226.14	233.72	241.50	249.50	257.72	266.16	274.82
150	283.70	292.80	302.15	311.75	321.60	331.70	342.05	352.65	363.50	374.60
160	386.00	397.65	409.60	421.80	434.30	447.10	460.20	473.60	487.25	501.25
170	515.60	530.20	545.20	560.45	576.10	592.05	608.35	625.05	642.05	659.45
180	677.15	695.30	713.75	732.65	751.90	771.50	–	–	–	–

* These tables of vapor pressures are quoted from results published by Ramsay and Young (Jour. Chem. Soc. vol. 47). The tables are intended to give a series suitable for hot-jacket purposes.

VAPOR PRESSURE.

Methyl Salicylate, Bromonaphthaline, and Mercury.

Temp. C.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
(e) Methyl Salicylate.										
70°	2.40	2.58	2.77	2.97	3.18	3.40	3.62	3.85	4.09	4.34
80	4.60	4.87	5.15	5.44	5.74	6.05	6.37	6.70	7.05	7.42
90	7.80	8.20	8.62	9.60	9.52	9.95	10.44	10.95	11.48	12.03
100	12.60	13.20	13.82	14.47	15.15	15.85	16.58	17.34	18.13	18.95
110	19.80	20.68	21.60	22.55	23.53	24.55	25.61	26.71	27.85	29.03
120	30.25	31.52	32.84	34.21	35.63	37.10	38.67	40.40	41.84	43.54
130	45.30	47.12	49.01	50.96	52.97	55.05	57.20	59.43	61.73	64.10
140	66.55	69.08	71.69	74.38	77.15	80.00	82.94	85.97	89.09	92.30
150	95.60	99.00	102.50	106.10	109.80	113.60	117.51	121.53	125.66	129.90
160	134.25	138.72	143.31	148.03	152.88	157.85	162.95	168.19	173.56	179.06
170	184.70	190.48	196.41	202.49	208.72	215.10	221.65	228.30	235.15	242.15
180	249.35	256.70	264.20	271.90	279.75	287.80	296.00	304.48	313.05	321.85
190	330.85	340.05	349.45	359.05	368.85	378.90	389.15	399.60	410.30	421.20
200	432.35	443.75	455.35	467.25	479.35	491.70	504.35	517.25	530.40	543.80
210	557.50	571.45	585.70	600.25	615.05	630.15	645.55	661.25	677.25	693.60
220	710.10	727.05	744.35	761.90	779.85	798.10				
(f) Bromonaphthaline.										
110°	3.60	3.74	3.89	4.05	4.22	4.40	4.59	4.79	5.00	5.22
120	5.45	5.70	5.96	6.23	6.51	6.80	7.10	7.42	7.76	8.12
130	8.50	8.89	9.29	9.71	10.15	10.60	11.07	11.56	12.07	12.60
140	13.15	13.72	14.31	14.92	15.55	16.20	16.87	17.56	18.28	19.03
150	19.80	20.59	21.41	22.25	23.11	24.00	24.92	25.86	26.83	27.83
160	28.85	29.90	30.98	32.09	33.23	34.40	35.60	36.83	38.10	39.41
170	40.75	42.12	43.53	44.99	46.50	48.05	49.64	51.28	52.96	54.68
180	56.45	58.27	60.14	62.04	64.06	66.10	68.19	70.34	72.55	74.82
190	77.15	79.54	81.99	84.51	87.10	89.75	92.47	95.26	98.12	101.05
200	104.05	107.12	110.27	113.50	116.81	120.20	123.67	127.22	130.86	134.59
210	138.40	142.30	146.29	150.38	154.57	158.85	163.25	167.70	172.30	176.95
220	181.75	186.65	191.65	196.75	202.00	207.35	212.80	218.40	224.15	230.00
230	235.95	242.05	248.30	254.65	261.20	267.85	274.65	281.60	288.70	295.95
240	303.35	310.90	318.65	326.50	334.55	342.75	351.10	359.65	368.40	377.30
250	386.35	395.60	405.05	414.65	424.45	434.45	444.65	455.00	465.60	476.35
260	487.35	498.55	509.90	521.50	533.35	545.35	557.60	570.05	582.70	595.60
270	608.75	622.10	635.70	649.50	663.55	677.85	692.40	707.15	722.15	737.45
(g) Mercury.										
270°	123.92	126.97	130.08	133.26	136.50	139.81	143.18	146.61	150.12	153.70
280	157.35	161.07	164.86	168.73	172.67	176.79	180.88	185.05	189.30	193.63
290	198.04	202.53	207.10	211.76	216.50	221.33	226.25	231.25	236.34	241.53
300	246.81	252.18	257.65	263.21	268.87	274.63	280.48	286.43	292.49	298.66
310	304.93	311.30	317.78	324.37	331.08	337.89	344.81	351.85	359.00	366.28
320	373.67	381.18	388.81	396.56	404.43	412.44	420.58	428.83	437.22	445.75
330	454.41	463.20	472.12	481.19	490.40	499.74	509.22	518.85	528.63	538.56
340	548.64	558.87	569.25	579.78	590.48	601.33	612.34	623.51	634.85	646.36
350	658.03	669.86	681.86	694.04	706.40	718.94	731.65	744.54	757.61	770.87
360	784.31									

TABLE 234.

AIR AND MERCURY THERMOMETERS.

Rowland has shown (Proc. Am. Acad. Sci. vol. 15) that, when 0° and 100° are chosen for fixed points, the relation between the readings of the air and the mercury in glass thermometers can be very nearly expressed by an equation of the form

$$t = T - at(100 - t)(b - t),$$

where t is the reading of the air thermometer and T that of the mercury one, a and b being constants. The smaller a is, the more nearly will the thermometers agree at all points, and there will be absolute agreement for $t = 0$ or 100 or b.

Regnault found that a mercury thermometer of ordinary glass gave too high a reading between 0° and 100°, and too low a reading between 100° and about 245°. As to some other thermometers experimented on by Regnault, little is recorded of their performance between 0° and 100°, but all of them gave too high readings above 100°, indicating that below 100° the mercury thermometer probably reads too low. Regnault states this to be the case for a thermometer of Choisy le Roi crystal glass, and puts the maximum error at from one tenth to two tenths of a degree. Regnault's comparisons of the air and mercury thermometers and a comparison by Recknagel of a mercury thermometer of common glass with the air thermometer are compared with the above formula by Rowland. The tables are interesting as showing approximately the error to be expected in the use of a mercury thermometer and the magnitude of the constants a and b for different glasses. They are given in the following Table.

Regnault's results above 100° C. compared with the formula $t = T - at(100 - t)(b - t)$, give for the constants a and b the following values:

Cristal de Choisy le Roi .	$a = 0.00000032$,	$b = 0°$.
Verre ordinaire . . .	$a = 0.00000034$,	$b = 245°$.
Verre vert	$a = 0.000000095$,	$b = -270°$.*
Verre de Suède . . .	$a = 0.00000014$,	$b = 10°$.
Common glass (Recknagel)	$a = 0.00000033$,	$b = 290°$.

(a) TEMPERATURES BETWEEN 0° AND 100° C.

There are no observed results with which to compare the calculations for the Choisy le Roi thermometer through this range, and in the case of the *verre ordinaire*, the specimen for which the readings below 100° are given was not the same as that used above 100°, from which the constants a and b were calculated. Rowland shows that $a = 0.00000044$ and $b = 260$ give considerably better agreement.

Air thermometer.	Regnault's thermometers.				Recknagel's thermometer.		
	Choisy le Roi. Calculated.	Verre ordinaire. Observed.	Verre ordinaire. Calculated.	Difference.	Observed.	Calculated.	Difference.
0	00.00	00.00	00.00	-	00.00	00.00	.00
10	10.00	-	10.07	-	10.08	10.08	.00
20	19.99	-	20.12	-	20.14	20.14	.00
30	29.98	30.12	30.15	+.03	30.18	30.18	.00
40	30.97	40.23	40.17	—.06	40.20	40.20	.00
50	49.96	50.23	50.17	—.06	50.20	50.20	.00
60	59.95	60.24	60.15	—.09	60.18	60.18	.00
70	69.95	70.22	70.12	—.10	70.14	70.15	+.01
80	79.96	80.10	80.09	—.01	80.10	80.11	+.01
90	89.97	-	90.05	-	90.05	90.06	+01
100	100.00	100.00	100.00	-	100.00	100.00	+.0

(b) TEMPERATURES ABOVE 100° C., REGNAULT'S THERMOMETERS.

Air ther.	Choisy le Roi.			Verre ordinaire.			Verre vert.			Verre de Suède.		
	Obs.	Calc.	Diff.	Obs.	Calc.	Diff.	Obs.	Calc.	Diff.	Obs.	Calc.	Diff.
100	100.00	100.00	+.00	100.00	100.00	.00	100.00	100.00	.00	100.00	100.00	.00
120	120.12	120.09	+.03	119.95	119.90	+.05	120.07	120.09	—.01	120.04	120.04	.00
140	140.29	140.25	+.04	139.85	139.80	+.05	140.21	140.22	—.01	140.11	140.10	+.01
160	160.52	160.[illegible]	+.03	159.74	159.72	+.02	160.40	160.39	+.01	160.20	160.21	—.01
180	180.80	180.8[illegible]	—.03	179.63	179.68	—.05	180.60	180.62	—.02	180.33	180.34	—.01
200	201.25	201.[illegible]	—.03	199.70	199.69	+.01	200.80	200.89	—.09	200.50	200.53	—.03
220	221.82	221.8[illegible]	—.04	219.80	219.78	+.02	221.20	221.23	—.03	220.75	220.78	—.03
240	242.55	242.56	—.01	239.90	239.96	—.06	241.60	241.63	—.03	241.16	241.08	+.08
260	263.44	263.46	—.02	260.20	260.21	—.01	262.15	262.09	+.07			
280	284.48	284.52	—.04	280.58	280.00	—.02	282.85	282.63	+.22			
300	305.72	305.76	—.04	301.08	301.12	—.04						
320	327.25	327.20	—.05	321.80	321.80	.00						
340	349.30	348.88	+.42	343.00	342.64	+.36						

* Misprinted [+] 270 in Rowland's paper.

COMPARISON OF THERMOMETERS.*

Chappius gives the following equations for comparing glass thermometers:

$$1000(T_N - T_H) = .00543(100 - T_m)\,T_m + 1.412 \times 10^{-4}(100^2 - T_m^2)\,T_m - 1.323 \times 10^{-6}(100^3 - T_m^3)\,T_m.$$

$$1000(T_{CO_2} - T_H) = .0359(100 - T_m)\,T_m - 0.234 \times 10^{-4}(100^2 - T_m^2)\,T_m - 0.510 \times 10^{-6}(100^3 - T_m^3)\,T_m.$$

N = nitrogen; H = hydrogen; CO_2 = carbon dioxide; m = mercury.

TABLE 235. — Hydrogen Thermometer compared with others.

This table gives the correction which added to the thermometer reading gives the temperature by the hydrogen thermometer.

Temperature by hydrogen thermometer.	Chappius's experiments.†			Marek's experiments.‡				
				Mercury in glass.				
	Hard French glass mercury thermometer.	Nitrogen thermometer.	Carbon dioxide thermometer.	Hard French glass.	French crystal glass.	Jena normal glass.	Thuringian glass. 1830–40.	Thuringian glass. 1888.
—20	+0.172	+0.014	+0.071					
—10	+0.073	+0.007	+0.032					
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	—0.052	—0.006	—0.025	—0.044	—0.060	—0.056	—0.086	—0.072
20	—0.085	—0.010	—0.043	—0.073	—0.100	—0.091	—0.149	—0.125
30	—0.102	—0.011	—0.054	—0.091	—0.125	—0.109	—0.191	—0.159
40	—0.107	—0.011	—0.059	—0.098	—0.134	—0.111	—0.213	—0.178
50	—0.103	—0.009	—0.059	—0.096	—0.132	—0.103	—0.216	—0.180
60	—0.090	—0.005	—0.053	—0.086	—0.118	—0.086	—0.201	—0.168
70	—0.072	—0.001	—0.044	—0.070	—0.096	—0.064	—0.171	—0.143
80	—0.050	+0.002	—0.030	—0.050	—0.068	—0.041	—0.127	—0.106
90	—0.026	+0.003	—0.016	—0.026	—0.035	—0.018	—0.069	—0.058
100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 236. — Air Thermometer compared with others.

This table gives the correction which added to the thermometer reading gives the temperature by the air thermometer.

Temperature by air thermometer.	Mercury in Thuringian glass thermometer (Grommach §).	Mercury in Jena glass thermometer (Wiebe and Böttcher ‖).	Temperature by air thermometer.	Mercury in Jena glass thermometer (Wiebe and Böttcher ‖).	Temperature by air thermometer.	Baudin alcohol thermometer (White ¶).
—20	+0.03	+0.153	130	—0.07	0	—0.000
—10	+0.02	+0.067	140	—0.09	—5	—0.144
0	0.00	0.000	150	—0.10	—10	—0.382
10	—0.03	—0.049	160	—0.10	—15	—0.704
20	—0.11	—0.083	170	—0.08	—20	—1.100
30	—0.12	—0.103	180	—0.06	—25	—1.563
40	—0.08	—0.110	190	—0.02	—30	—2.082
50	-	—0.107	200	+0.04	—35	—2.648
54	—0.04	-	210	+0.11	—40	—3.253
60	-	—0.096	220	+0.21	—45	—3.887
70	-	—0.078	230	+0.32	—50	—4.541
73	—0.06	-	240	+0.46	—55	—5.206
80	-	—0.054	250	+0.63	—60	—5.872
82	—0.04	-	260	+0.82	—65	—6.531
90	-	—0.028	270	+1.05	—70	—7.174
100	-	0.000	280	+1.30	—80	—8.371
110	-	—0.03	290	+1.58	—90	—9.392
120	-	—0.05	300	+1.91	—100	—10.163

* These two tables are taken with some slight alteration from Landolt and Boernstein's "Phys. Chem. Tab."
† P. Chappius, "Trav. et Mém. du Bur. internat. des Poids et Més." vol. 6, 1888.
‡ Marek, "Zeits. für Inst.-K." vol. 10, p. 283.
§ Grommach, "Metr. Beitr. heraus. v. d. Kaiser. Norm.-Aich. Comm." 1872.
‖ Wiebe und Böttcher, "Zeits. für Inst. K." vol. 10, p. 233.
¶ White, "Proc. Am. Acad. Sci." vol. 21, p. 45.

TABLE 237.

CHANGE OF THERMOMETER ZERO DUE TO HEATING.*

When a thermometer is used for measurements extending over a range of more than a few degrees, its indications are generally in error due to the change of volume of the glass lagging behind the change of temperature. Some data are here given to illustrate the magnitude of the change of zero after heating. This change is not permanent, but the thermometer may take several days or even weeks to return to its normal reading.

No. of experiment.	Maximum temp. in deg. cent.	Time at maximum temp. in hours.	Kind of glass. Normal Jena glass. I.	Normal Jena glass. II.	Thuringian glass.	Composition of Jena glass used.
			Depression of freezing-point.			
1	290	5	1.0	1.0	2.1	ZnO 7 %
2	290	5	1.3	1.5	2.7	CaO 7 %
3	290	5	1.5	1.7	3.1	Na_2O 14.5 %
4	290	5	1.6	1.8	3.4	Al_2O_3 2.5 %
5	290	5	1.7	1.9	3.6	B_2O_3 2 %
6	290	5	1.8	2.0	3.7	SiO_2 67 %
7	290	25	2.0	2.2	4.2	-

TABLE 238.

CHANGE OF THERMOMETER ZERO DUE TO HEATING.†

Description of thermometer.	Year of manufacture.	Ratio of soda and potash in the glass. Na_2O/K_2O	K_2O/Na_2O	Depression of zero due to one hour's heating to 100° C.
Humboldt, No. 2	Before 1835	0.04	-	0.06
J. G. Greiner, F_1	1848	0.08	-	0.15
" " F_2	1856	0.22	-	0.38
" " F_3	1872	-	0.21	0.38
Ch. F. Geissler, No. 13	1875	-	0.26	0.40
G. A. Schultze, No. 3	1875	-	0.24	0.44
Rapp's Successor, F_4	1878	-	0.83	0.65

* Allihn, "Zeits. für Anal. Chem." vol. 29, p. 385.
† W. Fresenius, "Zeits. für Anal. Chem." vol. 27, p. 189. See also, for this and following table, Wiebe in the "Zeitschrift für Instrumentenkunde," vol. 6, p. 167, from which Fresenius quotes. The thermometer referred to in this table belonged to the Kaiserlichen Normal-Aichungs Commission.

EFFECT OF COMPOSITION ON THERMOMETER ZERO.*

Jena Glasses.

Descriptive number.	Si_2O	Na_2O	K_2O	CaO	Al_2O_3	B_2O_3	ZnO	Depression of zero due to one hour's heating to 100° C.
IV	70	–	13.5	16.5	–	–	–	0.08
VIII	70	15	–	15	–	–	–	0.08
XXII	66	14	14	6	–	–	–	1.05
XXXI	66	11.1	16.9	6	–	–	–	1.03
$XVII^{III}$	69	15	10.5	–	5	–	–	1.06
XX^{III}	70	7.5	7.5	15	–	–	–	0.17
XIV^{III}	69	14	–	7	1	2	7	0.05
† XVI^{III}	67.5	14	–	7	2.5	2	7	0.05
XVIII	52	–	9	–	–	9	30	0.05

CHANGE OF ZERO OF THERMOMETER WITH TIME.

Closely allied to the changes illustrated in Tables 235–237 is the slow change of volume of the bulb of a thermometer with age. The following short table shows the change for the normal Jena thermometer.‡

Thermometer number.	Date of observation. 1886	1889	1890	Total rise.
	Rise of zero.			
106	0.00	0.3	0.04	0.04
108	0.01	0.2	0.04	0.03
665	0.01	0.3	0.05	0.04
667	0.02	0.4	0.05	0.03
668	0.02	0.5	0.06	0.04
670	0.00	0.3	0.04	0.04
671	0.05	0.9	0.09	0.04
672	0.05	0.8	0.08	0.03

* Fresenius, "Zeits. für Anal. Chem." vol. 27, p. 189.
† Normal Jena glass.
‡ Allihn, "Zeits. für Anal. Chem." vol. 29, p. 385.

TABLE 241.

CORRECTION FOR TEMPERATURE OF MERCURY IN THERMOMETER STEM.*

$T = t - 0.0000795\ n\ (t' - t)$, in Fahrenheit degrees; $T = t - 0.000143\ n\ (t' - t)$, in Centigrade degrees. Where T = corrected temperature, t = observed temperature, t' = mean temperature of glass stem and mercury column, n = the length of mercury in the stem in scale degrees.

(a) CORRECTION FOR FAHRENHEIT THERMOMETER = value of $0.0000795\ n\ (t' - t)$.

n	$t'-t$ 10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
10°	0.01	0.02	0.02	0.03	0.04	0.05	0.06	0.06	0.07	0.08
20	0.02	0.03	0.05	0.06	0.08	0.10	0.11	0.13	0.14	0.16
30	0.02	0.05	0.07	0.10	0.12	0.14	0.17	0.19	0.21	0.24
40	0.03	0.06	0.10	0.13	0.16	0.19	0.22	0.25	0.29	0.32
50	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.40
60	0.05	0.10	0.14	0.19	0.24	0.29	0.33	0.38	0.43	0.48
70	0.06	0.11	0.17	0.22	0.28	0.33	0.39	0.45	0.50	0.56
80	0.06	0.13	0.19	0.25	0.32	0.38	0.45	0.51	0.57	0.64
90	0.07	0.14	0.21	0.29	0.36	0.43	0.50	0.57	0.64	0.72
100	0.08	0.16	0.24	0.32	0.40	0.48	0.56	0.64	0.72	0.79
110	0.09	0.17	0.26	0.35	0.44	0.52	0.61	0.70	0.79	0.87
120	0.10	0.19	0.29	0.38	0.48	0.57	0.67	0.76	0.86	0.95
130	0.10	0.21	0.31	0.41	0.52	0.62	0.72	0.83	0.93	1.03

(b) CORRECTION FOR CENTIGRADE THERMOMETER = value of $0.000143\ n\ (t' - t)$.

n	$t'-t$ 10°	20°	30°	40°	50°	60°	70°	80°
10°	0.01	0.03	0.04	0.06	0.07	0.09	0.10	0.11
20	0.03	0.06	0.09	0.11	0.14	0.17	0.20	0.23
30	0.04	0.09	0.13	0.17	0.21	0.26	0.30	0.34
40	0.06	0.11	0.17	0.23	0.29	0.34	0.40	0.46
50	0.07	0.14	0.21	0.29	0.36	0.43	0.50	0.57
60	0.09	0.17	0.26	0.34	0.43	0.51	0.60	0.69
70	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80
80	0.11	0.23	0.34	0.46	0.57	0.69	0.80	0.92
90	0.13	0.26	0.39	0.51	0.64	0.77	0.90	1.03
100	0.14	0.29	0.43	0.57	0.72	0.86	1.00	1.14

N. B. — When $t' - t$ is negative the correction becomes additive.

* "Smithsonian Meteorological Tables," p. 12.

CORRECTION FOR TEMPERATURE OF MERCURY IN THERMOMETER STEM.

(*b*) CORRECTION TO BE ADDED TO THERMOMETER READING.*

n	$t-t'$										*n*
	70°	80°	90°	100°	120°	140°	160°	180°	200°	220°	
10°	0.02	0.03	0.05	0.07	0.11	0.17	0.21	0.27	0.33	0.38	**10°**
20	0.13	0.15	0.18	0.22	0.29	0.38	0.46	0.53	0.61	0.67	20
30	0.24	0.28	0.33	0.39	0.48	0.59	0.70	0.78	0.88	0.97	30
40	0.35	0.41	0.48	0.56	0.68	0.82	0.94	1.04	1.16	1.28	40
50	0.47	0.53	0.62	0.72	0.88	1.03	1.17	1.31	1.44	1.59	**50**
60	0.57	0.66	0.77	0.89	1.09	1.25	1.42	1.58	1.74	1.90	60
70	0.69	0.79	0.92	1.06	1.30	1.47	1.67	1.86	2.04	2.23	70
80	0.80	0.91	1.05	1.21	1.52	1.71	1.94	2.15	2.33	2.55	80
90	0.91	1.04	1.19	1.38	1.73	1.96	2.20	2.42	2.64	2.89	**90**
100	1.02	1.18	1.35	1.56	1.97	2.18	2.45	2.70	2.94	3.23	100
110	–	–	–	1.78	2.19	2.43	2.70	2.98	3.26	3.57	110
120	–	–	–	1.98	2.43	2.69	2.95	3.26	3.58	3.92	120
130	–	–	–	–	2.68	2.94	3.20	3.56	3.89	4.28	**130**
140	–	–	–	–	2.92	3.22	3.47	3.86	4.22	4.64	140
150	–	–	–	–	–	–	3.74	4.15	4.56	5.01	150
160	–	–	–	–	–	–	4.00	4.46	4.90	5.39	160
170	–	–	–	–	–	–	4.27	4.76	5.24	5.77	**170**
180	–	–	–	–	–	–	4.54	5.07	5.59	6.15	180
190	–	–	–	–	–	–	–	5.38	5.95	6.54	190
200	–	–	–	–	–	–	–	5.70	6.30	6.94	200
210	–	–	–	–	–	–	–	–	6.68	7.35	**210**
220	–	–	–	–	–	–	–	–	7.04	7.75	220

* This table is quoted from Rimbach's results, "Zeit. für Instrumentenkunde," vol. 10, p. 153. The numbers represent the correction made by direct experiment for thermometers of Jena glass graduated from 0° to 360° C., the degrees being from 1 to 1.6 mm. long. The first column gives the length of the mercury in the part of the stem which is exposed in the air, and the headings under $t-t'$ give the difference between the observed temperature and that of the air.

EMISSIVITY.

TABLE 242. — Emissivity at Ordinary Pressures.

According to McFarlane* the rate of loss of heat by a sphere placed in the centre of a spherical enclosure which has a blackened surface, and is kept at a constant temperature of about 14° C., can be expressed by the equations

$$e = .000238 + 3.06 \times 10^{-6}t - 2.6 \times 10^{-8}t^2,$$

when the surface of the sphere is blackened, or

$$e = .000168 + 1.98 \times 10^{-6}t - 1.7 \times 10^{-8}t^2,$$

when the surface is that of polished copper. In these equations e is the emissivity in c. g. s. units, that is, the quantity of heat, in therms, radiated per second per square centimetre of surface of the sphere, per degree difference of temperature t, and t is the difference of temperature between the sphere and the enclosure. The medium through which the heat passed was moist air. The following table gives the results.

Difference of temperature t	Value of e. Polished surface.	Value of e. Blackened surface.	Ratio.
5	.000178	.000252	.707
10	.000186	.000266	.699
15	.000193	.000279	.692
20	.000201	.000289	.695
25	.000207	.000298	.694
30	.000212	.000306	.693
35	.000217	.000313	.693
40	.000220	.000319	.693
45	.000223	.000323	.690
50	.000225	.000326	.690
55	.000226	.000328	.690
60	.000226	.000328	.690

TABLE 243. — Emissivity at Different Pressures.

Experiments made by J. P. Nicol in Tait's Laboratory show the effect of pressure of the enclosed air on the rate of loss of heat. In this case the air was dry and the enclosure kept at about 8° C.

Polished surface. t	Polished surface. et	Blackened surface. t	Blackened surface. et
PRESSURE 76 CMS. OF MERCURY.			
63.8	.00987	61.2	.01746
57.1	.00862	50.2	.01360
50.5	.00736	41.6	.01078
44.8	.00628	34.4	.00860
40.5	.00562	27.3	.00640
34.2	.00438	20.5	.00455
29.6	.00378	–	–
23.3	.00278	–	–
18.6	.00210	–	–
PRESSURE 10.2 CMS. OF MERCURY.			
67.8	.00492	62.5	.01298
61.1	.00433	57.5	.01158
55	.00383	53.2	.01048
49.7	.00340	47.5	.00898
44.9	.00302	43.0	.00791
40.8	.00268	28.5	.00490
PRESSURE 1 CM. OF MERCURY.			
65	.00388	62.5	.01182
60	.00355	57.5	.01074
50	.00286	54.2	.01003
40	.00219	41.7	.00726
30	.00157	37.5	.00639
23.5	.00124	34.0	.00569
–	–	27.5	.00446
–	–	24.2	.00391

* "Proc. Roy. Soc." 1872.
† "Proc. Roy. Soc." Edinb. 1869.

EMISSIVITY.

TABLE 244. — Constants of Emissivity.

The constants of radiation into vacuum have been determined for a few substances. The object of several of the investigations has been the determination of the law of variation with temperature or the relative merits of Dulong and Petit's and of Stefan's law of cooling.

Dulong and Petit's law gives for the amount of heat radiated in a given time the equation

$$H = Asa^{\theta}(a^{t} - 1)$$

where A is a constant depending on the units employed and on the nature of the surface, s the surface, a a constant determined by Dulong and Petit to be 1.0077, θ the absolute temperature of the enclosure, and t the difference of temperature between the hot surface and the enclosure. The following values of A are taken from the experiments of W. Hopkins, the results being reduced to centimetre second units, and the therm as unit of heat.

Glass	$A = .00001327$
Dry chalk	$A = .00001195$
Dry new red-sandstone	$A = .00001162$
Sandstone (building) .	$A = .00001232$
Polished limestone . .	$A = .00001263$
Unpolished limestone (same block) . . .	$A = .0001777$

Stefan's law is expressed by the equation

$$H = \sigma s(T_1^4 - T_0^4),$$

where H and s have the same meaning as above, σ is a constant, called Stefan's radiation constant, T_1 is the absolute temperature of the radiating body and T_0 the absolute temperature of the enclosure. Stefan's constant would represent, if the law held to absolute zero, the amount of heat which would be radiated per unit surface from the body at 1° absolute temperature to space at absolute zero. The experiments of Schleiermacher, Bottomley, and others show that this law approximates to the actual radiation only through a limited range of temperature.

Graetz * finds for glass	$T_1 = 400,\ T_0 = 0,\ \sigma = 1.0846 \times 10^{-12}$
Schleiermacher † find for polished platinum wire .	$T_1 = 1085,\ T_0 = 0,\ \sigma = 0.185 \times 10^{-12}$ $T_1 = 1150,\ T_0 = 0,\ \sigma = 0.177 \times 10^{-12}$
For copper oxide	$T_1 = 850,\ T_0 = 0,\ \sigma = 0.600 \times 10^{-12}$ $T_1 = 1080,\ T_0 = 0,\ \sigma = 0.701 \times 10^{-12}$

TABLE 245. — Effect of Absolute Temperature of Surface.

The following tabular results are given by Bottomley.‡ The results of Schleiermacher were calculated from data given in the paper above quoted. The temperatures t_1 are in degrees centigrade, and e is the emissivity or amount of heat in therms radiated per square centimetre of surface per degree difference of temperature between the hot body and the enclosure. The results are all for high vacuum.

Schleiermacher's results. Temperature of enclosure, 0° C. t_1e_1, t_3e_3, refer to polished platinum wire, t_2e_2 to blackened platinum wire.						Bottomley's results for polished platinum, the enclosures being at 15° C.	
t_1	e_1	t_2	e_2	t_3	e_3	t	e
130	21.6×10^{-6}	65	14.5×10^{-6}	16	60.9×10^{-6}	302	65.05×10^{-6}
200	30.0 "	110	18.7 "	38	67.6 "	425	120.3 "
337	53.8 "	232	32.2 "	94	83.7 "	613	282.0 "
581	137.0 "	383	61.6 "	228	147.0 "	744	537.0 "
826	315.0 "	740	198.0 "	403	293.0 "	806	653.0 "
		900	358.0 "	585	540.0 "		

* "Wied. Ann." vol. 11, p. 297.
† "Wied. Ann." vol. 26, p. 305.
‡ "Phil. Trans. Roy. Soc." 1887, p. 429.

EMISSIVITY.

TABLE 246. — Radiation of Platinum Wire to Copper Envelope.

Bottomley gives for the radiation of a bright platinum wire to a copper envelope when the space between is at the highest vacuum attainable the following numbers: —

$t = 408°$ C., $et = 378.8 \times 10^{-4}$, temperature of enclosure 16° C.
$t = 505°$ C., $et = 726.1 \times 10^{-4}$, " " 17° C.

It was found at this degree of exhaustion that considerable relative change of the vacuum produced very small change of the radiating power. The curve of relation between degree of vacuum and radiation becomes asymptotic for high exhaustions. The following table illustrates the variation of radiation with pressure of air in enclosure.

Temp. of enclosure 16° C., $t = 408°$ C.		Temp. of enclosure 17° C., $t = 505°$ C.	
Pressure in mm.	et	Pressure in mm.	et
740.	8137.0×10^{-4}	0.094	1688.0×10^{-4}
440.	7971.0 "	.053	1255.0 "
140.	7875.0 "	.034	1126.0 "
42.	7591.0 "	.013	920.4 "
4.	6036.0 "	.0046	831.4 "
0.444	2683.0 "	.00052	767.4 "
.070	1045.0 "	.00019	746.4 "
.034	727.3 "	Lowest reached but not measured	726.1 "
.012	539.2 "		
.0051	436.4 "		
.00007	378.8 "		

TABLE 247. — Effect of Pressure on Radiation at Different Temperatures.

The temperature of the enclosure was about 15° C. The numbers give the total radiation in therms per square centimetre per second.

Temp. of wire in C°.	Pressure in mm.				
	10.0	1.0	0.25	0.025	About 0.1 M.
100°	0.14	0.11	0.05	0.01	0.005
200	.31	.24	.11	.02	.0055
300	.50	.38	.18	.04	.0105
400	.75	.53	.25	.07	.025
500	–	.69	.33	.13	.055
600	–	.85	.45	.23	.13
700	–	–	–	.37	.24
800	–	–	–	.56	.40
900	–	–	–	–	.61

NOTE. — An interesting example (because of its practical importance in electric lighting) of the effect of difference of surface condition on the radiation of heat is given on the authority of Mr. Evans and himself in Bottomley's paper. The energy required to keep up a certain degree of incandescence in a lamp when the filament is dull black and when it is "flashed" with coating of hard bright carbon, was found to be as follows: —

Dull black filament, 57.9 watts.
Bright " " 39.8 watts.

PROPERTIES OF STEAM.

Metric Measure.

The temperature Centigrade and the absolute temperature in degrees Centigrade, together with other data for steam or water vapor stated in the headings of the columns, are here given. The quantities of heat are in therms or calories according as the gramme or the kilogramme is taken as the unit of mass.

Temp. C.	Absolute temp.	Pressure in mm. of mercury.	Pressure in grammes per sq. centimetre $=p$.	Pressure in atmospheres.	Total heat of evaporation from 0° at $t°=H$.	Heat of liquid $=h$.	Heat of evaporation $=H-h$.	Outer latent or external-work heat $=Apv$.*	Total heat of steam $=H-Apv$.	Inner latent or internal-work heat $=H-(h+Apv)$.	Litres per gramme, or cubic metres per kilog. $=v$.	Ratio of inner latent heat to volume of steam.†
0°	273	4.60	6.25	0.006	606.5	0.00	606.5	31.07	575.4	575.4	210.66	2.732
5	278	6.53	8.88	.009	608.0	5.00	603.0	31.47	576.5	571.5	150.23	3.805
10	283	9.17	12.47	.012	609.5	10.00	599.5	31.89	577.7	567.7	108.51	5.231
15	288	12.70	17.27	.017	611.1	15.00	596.0	32.32	578.8	563.7	79.35	7.104
20	293	17.39	23.64	.023	612.6	20.01	592.6	32.75	579.8	559.8	78.72	9.532
25	298	23.55	32.02	0.031	614.1	25.02	589.1	33.20	580.9	555.9	43.96	12.64
30	303	31.55	42.89	.042	615.6	30.03	585.6	33.66	582.0	552.0	33.27	16.59
35	308	41.83	56.87	.055	617.2	35.04	582.1	34.12	583.1	548.2	25.44	21.54
40	313	54.91	74.65	.072	618.7	40.05	587.6	34.59	584.1	544.1	19.64	27.70
45	318	71.39	97.06	.094	620.2	45.07	575.1	35.06	585.2	540.1	15.31	35.26
50	323	91.98	125.0	0.121	621.7	50.09	571.7	35.54	586.2	536.1	12.049	44.49
55	328	117.47	159.7	.155	623.3	55.11	568.2	36.02	587.2	532.1	9.561	55.65
60	333	148.79	202.3	.196	624.8	60.13	564.7	36.51	588.3	528.1	7.653	69.02
65	338	186.94	254.2	.246	626.3	65.17	561.1	37.00	589.3	524.2	6.171	84.94
70	343	233.08	316.9	.306	627.8	70.20	557.6	37.48	590.4	520.2	5.014	103.75
75	348	288.50	392.3	0.380	629.4	75.24	554.1	37.96	591.4	516.2	4.102	125.8
80	353	354.62	482.1	.446	630.9	80.28	550.6	38.42	592.5	512.2	3.379	151.6
85	358	433.00	588.7	.570	632.4	85.33	547.1	38.88	593.5	508.2	2.800	181.5
90	363	525.39	714.4	.691	633.9	90.38	543.6	39.33	594.6	504.2	2.334	216.0
95	368	633.69	861.7	.834	635.5	95.44	540.0	39.76	595.7	500.3	1.957	255.7
100	373	760.00	1033.	1.000	637.0	100.5	536.5	40.20	596.8	496.3	1.6496	300.8
105	378	906.41	1232.	.193	638.5	105.6	533.0	40.63	597.9	492.3	1.3978	352.2
110	383	1075.4	1462.	.415	640.0	110.6	529.4	41.05	599.0	488.4	1.1903	410.3
115	388	1269.4	1726.	.670	641.6	115.7	525.8	41.46	600.1	484.4	1.0184	475.6
120	393	1491.3	2027.	.962	643.1	120.8	522.3	41.86	601.2	480.4	0.8752	549.0
125	398	1743.9	2371.	2.295	644.6	125.9	518.7	42.25	602.4	476.5	0.7555	630.7
130	403	2030.3	2760.	2.671	646.1	131.0	515.1	42.63	603.5	472.5	0.6548	721.6
135	408	2353.7	3200.	3.097	647.7	136.1	511.6	43.01	604.7	468.6	0.5698	822.3
140	413	2717.6	3695.	3.576	649.2	141.2	508.0	43.38	605.8	464.6	0.4977	933.5
145	418	3125.6	4249.	4.113	650.7	146.3	504.4	43.73	607.0	460.7	0.4363	1055.7
150	423	3581.2	4869.	4.712	652.2	151.5	500.8	44.09	608.2	456.7	0.3839	1190.
155	428	4088.6	5589.	5.380	653.8	156.5	497.2	44.43	609.3	452.8	0.3388	1336.
160	433	4651.6	6324.	6.120	655.3	161.7	493.5	44.76	610.5	448.8	0.3001	1496.
165	438	5274.5	7171.	6.940	656.8	166.9	489.9	45.09	611.7	444.8	0.2665	1669.
170	443	5961.7	8105.	7.844	658.3	172.0	486.3	45.40	612.9	440.9	0.2375	1856.
175	448	6717.4	9133.	8.839	659.9	177.2	482.7	45.71	614.2	436.9	0.2122	2059.
180	453	7546.4	10260.	9.929	661.4	182.4	479.0	46.01	615.4	433.0	0.1901	2277.
185	458	8453.2	11490.	11.123	662.9	187.6	475.3	46.30	616.6	429.0	0.1708	2512.
190	463	9442.7	12838.	12.425	664.4	192.8	471.7	46.59	617.9	425.0	0.1538	2763.
195	468	10520.	14303.	13.842	666.0	198.0	468.0	46.86	619.1	421.1	0.1389	3031.
200	473	11689.	15892.	15.380	667.5	203.2	464.3	47.13	620.4	417.1	0.1257	3318.

* Where A is the reciprocal of the mechanical equivalent of the thermal unit.

† $=\frac{H-(h+Apv)}{v}=\frac{\text{internal-work pressure}}{\text{mechanical equivalent of heat}}$. Where v is taken in litres the pressure is given per square decimetre, and where v is taken in cubic metres the pressure is given per square metre, — the mechanical equivalent being that of the therm and the kilogramme-degree or calorie respectively.

Table 249.

PROPERTIES OF STEAM.

British Measure.

The quantities given in the different columns of this table are sufficiently explained by the headings. The abbreviation B. T. U. stands for British thermal units. With the exception of column 3, which was calculated for this table, the data are taken from a table given by Dwelshauvers-Dery (Trans. Am. Soc. Mech. Eng. vol. xi.).

Pressure in pounds per square inch.	Pressure in pounds per square foot.	Pressure in atmospheres.	Temp. in degrees Fahr.	Volume per pound in cubic feet.	Weight per cubic foot in pounds.	Heat of water per pound in B. T. U.	Internal latent heat per pound of steam in B. T. U.	External latent heat per pound of steam in B. T. U.	Total latent heat per pound of steam in B. T. U.	Total heat per pound of steam in B. T. U.
1	144	0.068	102.0	334.23	0.0030	70.1	980.6	62.34	1043.	1113.0
2	288	.136	126.3	173.23	.0058	94.4	961.4	64.62	1026.	1120.4
3	432	.204	141.6	117.98	.0085	109.9	949.2	66.58	1011.	1127.0
4	576	.272	153.1	89.80	.0111	121.4	940.2	67.06	1007.	1128.6
5	720	.340	162.3	72.50	.0137	130.7	932.8	67.89	1001.	1131.4
6	864	0.408	170.1	61.10	0.0163	138.6	926.7	68.58	995.2	1133.8
7	1008	.476	176.9	53.00	.0189	145.4	921.3	69.18	990.5	1135.9
8	1152	.544	182.9	46.60	.0214	151.5	916.5	69.71	986.2	1137.7
9	1296	.612	188.3	41.82	.0239	156.9	912.2	70.18	982.4	1139.4
10	1440	.680	193.2	37.80	.0264	161.9	908.3	70.61	979.0	1140.9
11	1584	0.748	197.8	34.61	0.0289	166.5	904.8	70.99	975.8	1142.3
12	1728	.816	202.0	31.90	.0314	170.7	901.5	71.34	972.8	1143.5
13	1872	.884	205.9	29.58	.0338	174.7	898.4	71.68	970.0	1144.7
14	2016	.952	209.5	27.59	.0362	178.4	895.4	72.00	967.4	1145.9
15	2160	1.020	213.0	25.87	.0387	181.9	892.7	72.29	965.0	1146.9
16	2304	1.088	216.3	24.33	0.0411	185.2	890.1	72.57	962.7	1147.9
17	2448	.156	219.4	22.98	.0435	188.4	887.6	72.82	960.4	1148.9
18	2592	.224	222.4	21.78	.0459	191.4	885.3	73.07	958.3	1149.8
19	2736	.292	225.2	20.70	.0483	194.3	883.1	73.30	956.3	1150.6
20	2880	.360	227.9	19.72	.0507	197.0	880.9	73.53	954.4	1151.4
21	3024	1.429	230.5	18.84	0.0531	199.7	878.8	73.74	952.6	1152.2
22	3168	.497	233.0	18.03	.0554	202.2	876.8	73.94	950.8	1153.0
23	3312	.565	235.4	17.30	.0578	204.7	874.9	74.13	949.1	1153.7
24	3456	.633	237.7	16.62	.0602	207.0	873.1	74.32	947.4	1154.4
25	3600	.701	240.0	15.99	.0625	209.3	871.3	74.51	945.8	1155.1
26	3744	1.769	242.2	15.42	0.0649	211.5	869.6	74.69	944.3	1155.8
27	3888	.837	244.3	14.88	.0672	213.7	867.9	74.85	942.8	1156.4
28	4032	.905	246.3	14.38	.0695	215.7	866.3	75.01	941.3	1157.1
29	4176	.973	248.3	13.91	.0619	217.8	864.7	75.17	939.9	1157.7
30	4320	2.041	250.2	13.48	.0742	219.7	863.2	75.33	938.5	1158.3
31	4464	2.109	252.1	13.07	0.0765	221.6	861.7	75.47	937.2	1158.8
32	4608	.177	253.9	12.68	.0788	223.5	860.3	75.61	935.9	1159.4
33	4752	.245	255.7	12.32	.0811	225.3	858.9	75.76	934.6	1159.9
34	4896	.313	257.5	11.98	.0835	227.1	857.5	75.89	933.4	1160.5
35	5040	.381	259.2	11.66	.0858	228.8	856.1	76.02	932.1	1161.0
36	5184	2.449	260.8	11.36	0.0881	230.5	854.8	76.16	931.0	1161.5
37	5328	.517	262.5	11.07	.0903	232.2	853.5	76.28	929.8	1162.0
38	5472	.585	264.0	10.79	.0926	233.8	852.3	76.40	928.7	1162.5
39	5616	.653	265.6	10.53	.0949	235.4	851.0	76.52	927.6	1162.9
40	5760	.722	267.1	10.29	.0972	236.9	849.8	76.63	926.5	1163.4
41	5904	2.789	268.6	10.05	0.0995	238.5	848.7	76.75	925.4	1163.9
42	6048	.857	270.1	9.83	.1018	239.9	847.5	76.86	924.4	1164.3
43	6192	.925	271.5	9.61	.1040	241.4	846.4	76.97	923.3	1164.7
44	6336	.993	272.9	9.41	.1063	242.9	845.2	77.07	922.3	1165.2
45	6480	3.061	274.3	9.21	.1086	244.3	844.1	77.18	921.3	1165.6
46	6624	3.129	275.6	9.02	0.1108	245.6	843.1	77.29	920.4	1166.0
47	6768	.197	277.0	8.84	.1131	247.0	842.0	77.39	919.4	1166.4
48	6912	.265	278.3	8.67	.1153	248.3	841.0	77.49	918.5	1166.8
49	7056	.333	279.6	8.50	.1176	249.7	840.0	77.58	917.5	1167.2

PROPERTIES OF STEAM.

British Measure.

Pressure in pounds per square inch.	Pressure in pounds per square foot.	Pressure in atmospheres.	Temp. in degrees Fahr.	Volume per pound in cubic feet.	Weight per cubic foot in pounds.	Heat of water per pound in B. T. U.	Internal latent heat per pound of steam in B. T. U.	External latent heat per pound of steam in B. T. U.	Total latent heat per pound of steam in B. T. U.	Total heat per pound of steam in B. T. U.
50	7200	3.401	280.8	8.34	0.1198	251.0	839.0	77.67	916.6	1167.6
51	7344	.469	282.1	8.19	.1221	252.2	838.0	77.76	915.7	1168.0
52	7488	.537	283.3	8.04	.1243	253.5	837.0	77.85	914.9	1168.3
53	7632	.605	284.5	7.90	.1266	254.7	836.0	77.94	914.0	1168.7
54	7776	.673	285.7	7.76	.1288	256.0	835.1	78.03	913.1	1169.1
55	7920	3.741	286.9	7.63	0.1310	257.1	834.2	78.12	912.3	1169.4
56	8064	.801	288.1	7.50	.1333	258.3	833.2	78.21	911.5	1169.8
57	8208	.878	289.2	7.38	.1355	259.5	832.3	78.29	910.6	1170.1
58	8352	.946	290.3	7.26	.1377	260.7	831.5	78.37	909.8	1170.5
59	8496	4.014	291.4	7.14	.1400	261.8	830.6	78.45	909.0	1170.8
60	8640	4.082	292.5	7.03	0.1422	262.9	829.7	78.53	908.2	1171.2
61	8784	.150	293.6	6.92	.1444	264.0	828.9	78.61	907.5	1171.5
62	8928	.218	294.7	6.82	.1466	265.1	828.0	78.68	906.7	1171.8
63	9072	.286	295.7	6.72	.1488	266.1	827.2	78.76	905.9	1172.1
64	9216	.354	296.7	6.62	.1511	267.2	826.4	78.83	905.2	1172.4
65	9360	4.422	297.8	6.52	0.1533	268.3	825.6	78.90	904.5	1172.8
66	9504	.490	298.8	6.43	.1555	269.3	824.8	78.97	903.7	1173.1
67	9648	.558	299.8	6.34	.1577	270.4	824.0	79.04	903.1	1173.4
68	9792	.626	300.1	6.25	.1599	271.4	823.2	79.11	902.3	1173.7
69	9936	.694	301.8	6.17	.1621	272.4	822.4	79.18	901.6	1174.0
70	10080	4.762	302.7	6.09	0.1643	273.4	821.6	79.25	900.9	1174.3
71	10224	.830	303.7	6.00	.1665	274.3	820.9	79.32	900.2	1174.6
72	10368	.898	304.6	5.93	.1687	275.3	820.1	79.39	899.5	1174.9
73	10512	.966	305.5	5.85	.1709	276.3	819.4	79.46	898.8	1175.1
74	10656	5.034	306.5	5.78	.1731	277.2	818.7	79.53	898.1	1175.4
75	10800	5.102	307.4	5.70	0.1753	278.2	817.9	79.59	897.5	1175.7
76	10944	.170	308.3	5.63	.1775	279.1	817.2	79.65	896.9	1176.0
77	11088	.238	309.2	5.57	.1797	280.0	816.5	79.71	896.2	1176.2
78	11232	.306	310.1	5.50	.1818	280.9	815.8	79.77	895.6	1176.5
79	11376	.374	310.9	5.43	.1840	281.8	815.1	79.83	895.0	1176.8
80	11520	5.442	311.8	5.37	0.1862	282.7	814.4	79.89	894.3	1177.0
81	11664	.510	312.7	5.31	.1884	283.6	813.8	79.95	893.7	1177.3
82	11808	.578	313.5	5.25	.1906	284.5	813.0	80.01	893.1	1177.6
83	11952	.646	314.4	5.19	.1928	285.3	812.4	80.07	892.5	1177.8
84	12096	.714	315.2	5.13	.1949	286.2	811.7	80.13	891.9	1178.0
85	12240	5.782	316.0	5.07	0.1971	287.0	811.1	80.19	891.3	1178.3
86	11384	.850	316.8	5.02	.1993	287.9	810.4	80.25	890.7	1178.6
87	12528	.918	317.6	4.96	.2015	288.7	809.8	80.30	890.1	1178.9
88	12672	.986	318.4	4.91	.2036	289.5	809.2	80.35	889.5	1179.0
89	12816	6.054	319.2	4.86	.2058	290.4	808.5	80.40	888.9	1179.3
90	12960	6.122	320.0	4.81	0.2080	291.2	807.9	80.45	888.4	1179.5
91	13104	.190	320.8	4.76	.2102	292.0	807.3	80.50	887.8	1179.8
92	13248	.258	321.6	4.71	.2123	292.8	806.7	80.56	887.2	1180.0
93	13392	.327	322.4	4.66	.2145	293.6	806.1	80.61	886.7	1180.3
94	13536	.396	323.1	4.62	.2166	294.3	805.5	80.66	886.1	1180.5
95	13680	6.463	323.9	4.57	0.2188	295.1	804.9	80.71	885.6	1180.7
96	13824	.531	324.6	4.53	.2209	295.9	804.3	80.76	885.0	1180.9
97	13968	.599	325.4	4.48	.2231	296.7	803.7	80.81	884.5	1181.2
98	14112	.667	326.1	4.44	.2252	297.4	803.1	80.86	884.0	1181.4
99	14256	.735	326.8	4.40	.2274	298.2	802.5	80.91	883.4	1181.6

PROPERTIES OF STEAM.

British Measure.

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100	14400	6.803	327.6	4.356	0.2295	298.9	802.0	80.95	882.9	1181.8
101	14544	.871	328.3	.316	.2317	299.7	801.4	81.00	882.4	1182.1
102	14688	.939	329.0	.276	.2338	300.4	800.8	81.05	881.9	1182.3
103	14832	7.007	329.7	.237	.2360	301.1	800.3	81.10	881.4	1182.5
104	14976	.075	330.4	.199	.2381	301.9	799.7	81.14	880.8	1182.7
105	15120	7.143	331.1	4.161	0.2403	302.6	799.2	81.18	880.3	1182.9
106	15264	.211	331.8	.125	.2424	303.3	798.6	81.23	879.8	1183.1
107	15408	.279	332.5	.088	.2446	304.0	798.1	81.27	879.3	1183.4
108	15552	.347	333.2	.053	.2467	304.7	797.5	81.31	878.8	1183.6
109	15696	.415	333.8	.018	.2489	305.4	797.0	81.36	878.3	1183.8
110	15840	7.483	334.5	3.984	0.2510	306.1	796.5	81.41	877.9	1184.0
111	15984	.551	335.2	.950	.2531	306.8	795.9	81.45	877.4	1184.2
112	16128	.619	335.8	.917	.2553	307.5	795.4	81.50	876.9	1184.4
113	16272	.687	336.5	.885	.2574	308.2	794.9	81.54	876.4	1184.6
114	16416	.757	337.2	.853	.2596	308.8	794.4	81.58	875.9	1184.8
115	16560	7.823	337.8	3.821	0.2617	309.5	793.8	81.62	875.5	1185.0
116	16704	.891	338.5	.790	.2638	310.2	793.3	81.66	875.0	1185.2
117	16848	.959	339.1	.760	.2660	310.8	792.8	81.70	874.5	1185.4
118	16992	8.027	339.7	.730	.2681	311.5	792.3	81.74	874.1	1185.6
119	17136	.095	340.4	.700	.2702	312.1	791.8	81.78	873.6	1185.7
120	17280	8.163	341.0	3.671	0.2724	312.8	791.3	81.82	873.2	1185.9
121	17424	.231	341.6	.643	.2745	313.4	790.8	81.86	872.7	1186.1
122	17568	.299	342.2	.615	.2766	314.1	790.3	81.90	872.2	1186.3
123	17712	.367	342.8	.587	.2787	314.7	789.9	81.94	871.8	1186.5
124	17856	.435	343.5	.560	.2809	315.3	789.4	81.98	871.4	1186.7
125	18000	8.503	344.1	3.534	0.2830	316.0	788.9	82.02	870.9	1186.9
126	18144	.571	344.7	.507	.2851	316.6	788.4	82.06	870.5	1187.1
127	18288	.639	345.3	.481	.2872	317.2	787.9	82.09	870.0	1187.2
128	18432	.708	345.9	.456	.2893	317.8	787.5	82.13	869.6	1187.4
129	18576	.776	346.5	.431	.2915	318.4	787.0	82.17	869.2	1187.6
130	18720	8.844	347.1	3.406	0.2936	319.0	786.5	82.21	868.7	1187.8
131	18864	.912	347.6	.382	.2957	319.7	786.1	82.25	868.3	1188.0
132	19008	.980	348.2	.358	.2978	320.3	785.6	82.28	867.9	1188.1
133	19152	9.048	348.8	.334	.2999	320.9	785.1	82.32	867.5	1188.3
134	19296	.116	349.4	.310	.3021	321.5	784.7	82.35	867.0	1188.5
135	19440	9.184	349.9	3.287	0.3042	322.1	784.2	82.38	866.6	1188.7
136	19584	.252	350.5	.265	.3063	322.6	783.8	82.42	866.2	1188.8
137	19728	.320	351.1	.424	.3084	323.2	783.3	82.45	865.8	1189.0
138	19872	.388	351.6	.220	.3105	323.8	782.9	82.49	865.4	1189.2
139	20016	.456	352.2	.199	.3126	324.4	782.4	82.52	865.0	1189.4
140	20160	9.524	352.8	3.177	0.3147	325.0	782.0	82.56	864.6	1189.5
141	20304	.592	353.3	.156	.3168	325.5	781.6	82.59	864.2	1189.7
142	20448	.660	353.9	.135	.3190	326.1	781.1	82.63	863.8	1189.9
143	20592	.728	354.4	.115	.3211	326.7	780.7	82.66	863.4	1190.0
144	20736	.796	355.0	.094	.3232	327.2	780.3	82.69	863.0	1190.2
145	20880	9.864	355.5	3.074	0.3253	327.8	779.8	82.72	862.6	1190.4
146	21024	.932	356.0	.054	.3274	328.4	779.4	82.75	862.2	1190.5
147	21168	10.000	356.6	.035	.3295	328.9	779.0	82.79	861.8	1190.7
148	21312	.068	357.1	.016	.3316	329.5	778.6	82.82	861.4	1190.9
149	21456	.136	357.6	.997	.3337	330.0	778.1	82.86	861.0	1191.0

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150	21600	10.204	358.2	2.978	0.3358	330.6	777.7	82.89	860.6	1191.2
151	21744	.272	358.7	.960	.3379	331.1	777.3	82.92	860.2	1191.3
152	21888	.340	359.2	.941	.3400	331.6	776.9	82.95	859.9	1191.5
153	22032	.408	359.7	.923	.3421	332.2	776.5	82.98	859.5	1191.7
154	22176	.476	360.2	.906	.3442	332.7	776.1	83.01	859.1	1191.8
155	22320	10.544	360.7	2.888	0.3462	333.2	775.7	83.04	858.7	1192.0
156	22464	.612	361.3	.871	.3483	333.8	775.3	83.07	858.3	1192.1
157	22608	.680	361.8	.854	.3504	334.3	774.9	83.10	858.0	1192.3
158	22752	.748	362.3	.837	.3525	334.8	774.5	83.13	857.6	1192.4
159	22896	.816	362.8	.820	.3546	335.3	774.1	83.16	857.2	1192.6
160	23040	10.884	363.3	2.803	0.3567	335.9	773.7	83.19	856.9	1192.7
161	23184	.952	363.8	.787	.3588	336.4	773.3	83.22	856.5	1192.9
162	23328	11.020	364.3	.771	.3609	336.9	772.9	83.25	856.1	1193.0
163	23472	.088	364.8	.755	.3630	337.4	772.5	83.28	855.8	1193.2
164	23616	.157	365.3	.739	.3650	337.9	772.1	83.31	855.4	1193.3
165	23760	11.225	365.7	2.724	0.3671	338.4	771.7	83.34	855.1	1193.5
166	23904	.293	366.2	.708	.3692	338.9	771.3	83.37	854.7	1193.6
167	24048	.361	366.7	.693	.3713	339.4	771.0	83.39	854.3	1193.8
168	24192	.429	367.2	.678	.3734	339.9	770.6	83.42	854.0	1193.9
169	24336	.497	367.7	.663	.3754	340.4	770.2	83.45	853.6	1194.1
170	24480	11.565	368.2	2.649	0.3775	340.9	769.8	83.48	853.3	1194.2
171	24624	.633	368.6	.634	.3796	341.4	769.4	83.51	852.9	1194.4
172	24768	.701	369.1	.620	.3817	341.9	769.1	83.54	852.6	1194.5
173	24912	.769	369.6	.606	.3838	342.4	768.7	83.56	852.2	1194.7
174	25056	.837	370.0	.592	.3858	342.9	768.3	83.59	851.9	1194 8
175	25200	11.905	370.5	2.578	0.3879	343.4	767.9	83.62	851.6	1194.9
176	25344	.973	371.0	.564	.3900	343.9	767.6	83.64	851.2	1195.1
177	25488	12.041	371.4	.550	.3921	344.3	767.2	83.67	850.9	1195.2
178	25632	.109	371.9	.537	.3942	344.8	766.8	83.70	850.5	1195 4
179	25776	.177	372.4	524	.3962	345.3	766.5	83.73	850.2	1195.5
180	25920	12.245	372.8	2.510	0.3983	345.8	766.1	83.75	849.9	1195.6
181	26064	.313	373.3	.497	.4004	346.3	765.8	83.77	849.5	1195.8
182	26208	.381	373.7	.485	.4025	346.7	765.4	83.80	849.2	1195.9
183	26352	.449	374.2	.472	.4046	347.2	765.0	83.83	848.9	1196.1
184	26496	.517	374.6	.459	.4066	347.7	764.7	83.86	848.5	1196.2
185	26640	12.585	375.1	2.447	0.4087	348.1	764.3	83.88	848.2	1196.3
186	26784	.653	375.5	.434	.4108	348.6	764.0	83.90	847.9	1196.5
187	26928	.721	376.0	.422	.4129	349.1	763.6	83.92	847.5	1196.6
188	27072	.789	376.4	.410	.4150	349.5	763.3	83.95	847.2	1196.7
189	27216	.857	376.8	.398	.4170	350.0	762.9	83.97	846.9	1196.9
190	27360	12.925	377.3	2.386	0.4191	350.4	762.6	83.99	846.6	1197.0
191	27504	.993	377.7	.374	.4212	350.9	762.2	84.02	846.3	1197.1
192	27648	13.061	378.2	.362	.4233	351.3	761.9	84.04	845.9	1197.3
193	27792	.129	378.6	.351	.4254	351.8	761.6	84.06	845.6	1197.4
194	27936	.197	379.0	.339	.4275	352.2	761.2	84.08	845.3	1197.5
195	28080	13.265	379.4	2.328	0.4296	352.7	760.9	84.10	845.0	1197.7
196	28224	.333	379.9	.317	.4316	353.1	760.5	84.13	844.7	1197.8
197	28368	.401	380.3	.306	.4337	353.6	760.2	84.16	844.4	1197.9
198	28512	.469	380.7	.295	.4358	354.0	759.9	84.19	844.0	1198.1
199	28656	.537	381.1	.284	.4379	354.4	759.5	84.21	843.7	1198.2

PROPERTIES OF STEAM.

British Measure.

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200	28800	13.605	381.6	2.273	0.4399	354.9	759.2	84.23	843.4	1198.3
201	28944	13.673	382.0	.262	.4420	355.3	758.9	84.26	843.1	1198.4
202	29088	13.742	382.4	.252	.4441	355.8	758.5	84.28	842.8	1198.6
203	29232	13.810	382.8	.241	.4461	356.2	758.2	84.30	842.5	1198.7
204	29376	13.878	383.2	.231	.4482	356.6	757.9	84.33	842.2	1198.8
205	29520	13.946	383.7	2.221	0.4503	357.1	757.5	84.35	841.9	1199.0
206	29664	14.014	384.1	.211	.4523	357.5	757.2	84.37	841.6	1199.1
207	29808	14.082	384.5	.201	.4544	357.9	756.9	84.40	841.3	1199.2
208	29952	14.150	384.9	.191	.4564	358.3	756.6	84.42	841.0	1199.3
209	30096	14.218	385.3	.181	.4585	358.8	756.2	84.44	840.7	1199.4
210	30240	14.386	385.7	2.171	0.4605	359.2	755.9	84.46	840.4	1199.6
211	30384	14.454	386.1	.162	.4626	359.6	755.6	84.48	840.1	1199.7
212	30528	14.522	386.5	.152	.4646	360.0	755.3	84.51	839.8	1199.8
213	30672	14.590	386.9	.143	.4666	360.4	755.0	84.53	839.5	1199.9
214	30816	14.658	387.3	.134	.4687	360.9	754.7	84.55	839.2	1200.1
215	30960	14.726	387.7	2.124	0.4707	361.3	754.3	84.57	838.9	1200.2
216	31104	14.794	388.1	.115	.4727	361.7	754.0	84.60	838.6	1200.3
217	31248	14.862	388.5	.106	.4748	362.1	753.7	84.62	838.3	1200.4
218	31392	14.930	388.9	.097	.4768	362.5	753.4	84.64	838.0	1200.5
219	31536	14.998	389.3	.088	.4788	362.9	753.1	84.66	837.7	1200.7

RATIO OF THE ELECTROSTATIC TO THE ELECTROMAGNETIC UNIT OF ELECTRICITY (v) IN RELATION TO THE VELOCITY OF LIGHT.

Ratio of electrical units.			Reference.	
Date of determination.	v in cms. per sec.*	Determined by —	Publication.	Year.
1856	3.107×10^{10}	Weber & Kohlrausch	Pogg. Ann.	1856
1868	2.842×10^{10}	Maxwell	Phil. Trans.	1868
1869	2.808×10^{10}	W. Thomson & King	B. A. Report	1869
1872	2.896×10^{10}	McKichan	Phil. Trans.	1872
1879	2.960×10^{10}	Ayrton & Perry	Jour. Soc. Tel. Eng.	1879
1879	2.968×10^{10}	Hocken	B. A. Report	1879
1880	2.955×10^{10}	Shida	Phil. Mag.	1880
1881	2.99×10^{10}†	Stoletow	Soc. de Phys.	1881
1881	3.019×10^{10}	Klemenčič	Wien. Ber.	1884
1882	2.923×10^{10}	Exner	Wien. Ber.	1882
1883	2.963×10^{10}	J. J. Thomson	Phil. Trans.	1883
1888	3.009×10^{10}	Himstedt	Wied. Ann. 35	1888
1889	2.981×10^{10}	Rowland	Phil. Mag.	1889
1889	3.000×10^{10}	Rosa	" "	1889
1889	3.004×10^{10}	W. Thomson	Phil. Mag.	1889
1890	2.995×10^{10}	J. J. Thomson & Searle	Phil. Trans.	1890

* The results in this column correspond to a value of the B. A. ohm $= .98664 \times 10^9$ cms. per sec. If we neglect the first four determinations, and also that of Exner and Shida, because of their large deviation from the mean, the remaining determinations give a mean value of $2.9889 + .0137$, a value which practically agrees with the best determinations of the velocity of light. (Cf. Table 181.)

† Given as between 2.98×10^{10} and 3.00×10^{10}.

DIELECTRIC STRENGTH.

Difference of Electric Potential required to produce a Spark in Air.

(a) MEDIUM, AIR. ELECTRODE TERMINALS, FLAT PLATES.

Spark length in centimetres.	Difference of potential in volts required to produce a spark according to —				
	W. Thomson.[1]	De la Rue.[2]	MacFarlane.[3]	Baille.[4]	Freyberg.[5]
0.01	790	500	-	-	-
0.02	1340	970	-	-	-
0.04	1840	1900	-	-	-
0.07	2940	3170	-	-	-
0.10	4010	4330	3507	4401	4344
0.14	5300	5740	-	-	-
0.20	-	7620	5715	7653	7539
0.30	-	10400	7818	10603	10671
0.40	-	-	9879	13431	13665
0.50	-	-	11925	16341	16293
0.60	-	-	13956	19146	19059
0.80	-	-	18006	25458	24465
1.00	-	-	22044	31647	28800

1 "Reprint of Papers on Elect. and Mag." p. 252.
2 "Proc. R. Soc." vol. 36, p. 151.
3 "Phil. Mag." vol. 10, 1880.
4 "Ann. de Chim. et de Phys." vol. 25, 1882.
5 "Wied. Ann." vol. 38, 1889.

(b) MEDIUM, AIR. ELECTRODE TERMINALS, BALLS OF DIAMETER d IN CENTIMETRES.

Experiments of Freyberg.

Spark length in centimetres.	$d = 0$ (points).	$d = 0.50$	$d = 1.0$	$d = 2.0$	$d = 4.0$	$d = 6.0$
0.1	3720	5050	4660	4560	-	4530
0.2	4700	8600	9500	8700	8400	7900
0.3	5300	11100	11700	11600	11200	10500
0.4	6000	13500	14000	14400	14200	12800
0.6	6900	16600	19300	19500	20100	19200
0.8	8100	18400	23200	24600	25800	26000
1.0	8600	19500	25800	29000	29900	31600
2.0	10100	24600	35400	-	-	-
5.0	13100	30700	-	-	-	-

From the above table it appears, as remarked by Freyberg, that for each length of spark there is a particular size of ball which requires the greatest difference of potential to produce the spark.

(c) COMPARISON OF RESULTS OF DETERMINATIONS, THE TERMINALS BEING BALLS.

Spark length in cms.	Difference of potential required to produce a spark in air according to —								
	Baille.	Bichat and Blondlot.[1]	Paschen.	Freyberg.	Paschen.	Freyberg.	Quincke.[2]	Baille.	Freyberg.
	Balls 1 centimetre diameter.				Balls 2 cms. diameter.			Balls 6 cms. diam.	
.1	4590	4200	4860	4660	4830	4560	4440	4440	4530
.2	8040	8130	8430	9500	8340	8700	7920	7680	7860
.3	11190	10860	11670	11670	11670	11550	11190	10830	10470
.4	13650	14130	14830	13980	14820	14400	14010	13500	12750
.5	16410	16800	17760	16800	18030	17040	16920	16530	16410
.6	19560	19350	20460	19260	20820	19470	19980	19560	19200
.7	21690	21030	22640	20970	23670	22530	22590	22620	22590
.8	23280	23190	24780	23220	-	24630	25770	26400	26010
.9	24030	24540	-	25110	-	27240	-	29220	28770
1.0	24930	25800	-	25770	-	29040	-	33870	31620

1 "Electricien," Aug. 1886.
2 "Wied. Ann." vol. 19, 1883.

DIELECTRIC STRENGTH.

TABLE 252. — Effect of Pressure of the Gas on the Dielectric Strength.*

Length of spark is indicated by l in centimetres. The pressure is in centimetres of mercury at 0° C.

Pressure.	Hydrogen.			Air.			Carbon dioxide.		
	$l=0.2$	$l=0.4$	$l=0.6$	$l=0.2$	$l=0.4$	$l=0.6$	$l=0.2$	$l=0.4$	$l=0.6$
2	510	606	-	819	1202	1536	1125	1446	1650
4	729	1017	1437	1140	1725	2289	1431	1971	2373
6	945	1323	1839	1455	2229	3012	1755	2484	3105
8	1098	1572	2172	1740	2721	3684	2070	2913	3813
10	1242	1806	2463	2004	3186	4272	2355	3288	4278
15	1584	2376	3330	2664	4212	5736	2991	4227	5592
20	1866	2937	4020	3294	5205	7074	3705	5235	6801
25	2169	3444	4668	3816	6108	8346	4248	6120	8004
30	2475	3957	5331	4347	7020	9570	4707	6921	9147
35	2748	4407	5997	4845	7980	10797	5163	7737	10293
40	3051	4863	6681	5349	8853	12009	5772	8543	11397
45	3339	5334	7347	5853	9639	13224	6222	9303	12483
50	3606	5829	7971	6288	10431	14361	6489	10038	13557
55	2834	6294	8583	6711	11259	15441	6789	10650	14610
60	4107	6747	9222	7134	12084	16548	7197	11397	15702
65	4476	7197	9867	7569	12885	17688	7605	12114	16740
70	4731	7629	10476	8016	13710	18804	8001	12816	17727
75	4914	8031	11040	8487	14523	19896	8388	13506	18705

Paschen deduces from the above, and also shows by separate experiments, that if the product of the pressure of the gas and the length of spark be kept constant the difference of potential required to produce the spark also remains constant.

In the following short table l is length of spark, P pressure, and V difference of potential, the unit being the same as above. The table illustrates the potential difference required to produce a spark for different values of tl e product $l.P.$

$l.P.$	V for H	V for Air.	V for CO_2	$l.P.$	V for H	V for Air.	V for CO_2
0.2	456	669	873	6.0	2481	4251	4443
0.4	567	837	1110	10.0	3507	6162	6198
0.6	660	996	1281	20.0	5835	10392	10011
1.0	846	1326	1599	30.0	8004	13448	13527
2.0	1427	2019	2271	45.0	11013	19848	18705
4.0	1884	3216	3468				

TABLE 253. — Dielectric Strength (or Difference of Potential per Centimetre of Spark Length) of Different Substances, in Kilo Volts.†

Substance.	Dielectric strength.	Substance.	Dielectric strength.	Substance.	Dielectric strength.
Air (thickness 5 mm.) .	23.8	Beeswaxed paper .	540.	Kerosene oil . . .	50.
Carbon dioxide " . .	22.7	Paraffined paper .	360.	Oil of turpentine .	94.
Coal gas " . .	15.1	Paraffin (solid) . .	130.	Olive oil	82.
Hydrogen " . .	22.2			Paraffin oil . . .	87.
Oxygen " . .	22.3			Paraffin (melted) .	56.

* Paschen.
† MacFarlane and Pierce, "Phys. Rev." vol. 1, p. 165, 1893.

TABLE 254.

COMPOSITION AND ELECTROMOTIVE FORCE OF BATTERY CELLS.

The electromotive forces given in this table approximately represent what may be expected from a cell in good working order, but with the exception of the standard cells all of them are subject to considerable variation.

(a) DOUBLE FLUID BATTERIES.

Name of cell.	Negative pole.	Solution.	Positive pole.	Solution.	E.M.F. in volts.
Bunsen . .	Amalgamated zinc	1 part H_2SO_4 to 12 parts H_2O .	Carbon	Fuming H_2NO_3 .	1.94
" . .	" "	"	"	HNO_3, density 1.38	1.86
Chromate .	" "	12 parts $K_2Cr_2O_7$ to 25 parts of H_2SO_4 and 100 parts H_2O . .	"	1 part H_2SO_4 to 12 parts H_2O .	2.00
" .	" "	1 part H_2SO_4 to 12 parts H_2O .	"	12 parts $K_2Cr_2O_7$ to 100 parts H_2O	2.03
Daniell* .	" "	1 part H_2SO_4 to 4 parts H_2O .	Copper	Saturated solution of $CuSO_4+5H_2O$	1.06
" .	" "	1 part H_2SO_4 to 12 parts H_2O .	"	"	1.09
" .	" "	5% solution of $ZnSO_4+6H_2O$	"	"	1.08
" .	" "	1 part NaCl to 4 parts H_2O .	"	"	1.05
Grove . .	" "	1 part H_2SO_4 to 12 parts H_2O .	Platinum	Fuming HNO_3 . .	1.93
" . .	" "	Solution of $ZnSO_4$	"	HNO_3, density 1.33	1.66
" . .	" "	H_2SO_4 solution, density 1.136 .	"	Concentrated HNO_3	1.93
" . .	" "	H_2SO_4 solution, density 1.136 .	"	HNO_3, density 1.33	1.79
" . .	" "	H_2SO_4 solution, density 1.06 .	"	"	1.71
" . .	" "	H_2SO_4 solution, density 1.14 .	"	HNO_3, density 1.19	1.66
" . .	" "	H_2SO_4 solution, density 1.06 .	"	" " "	1.61
" . .	" "	NaCl solution . .	"	" density 1.33	1.88
Marié Davy	" "	1 part H_2SO_4 to 12 parts H_2O	Carbon	Paste of protosulphate of mercury and water . . .	1.50
Partz . .	" "	Solution of $MgSO_4$	"	Solution of $K_2Cr_2O_7$	2.06

* The Minotto or Sawdust, the Meidinger, the Callaud, and the Lockwood cells are modifications of the Daniell, and hence have about the same electromotive force.

COMPOSITION AND ELECTROMOTIVE FORCE OF BATTERY CELLS.

Name of cell.	Negative pole.	Solution.	Positive pole.	E. M. F. in volts.
(b) SINGLE FLUID BATTERIES.				
Leclanche . . .	Amal. zinc	Solution of sal-ammoniac	Carbon surrounded by powdered carbon and peroxide of manganese	1.46
Chaperon . . .	"	Solution of caustic potash	Copper and CuO	0.98
Edison-Lelande .	"	"	"	0.70
Chloride of silver	Zinc . .	23 % solution of sal-ammoniac . . .	Silver surrounded by silver chloride	1.02
Law	"	15 % " "	Carbon	1.37
Dry cell (Gassner)	"	1 pt. ZnO, 1 pt. NH_4Cl, 3 pts. plaster of paris, 2 pts. $ZnCl_2$, and water to make a paste . .	"	1.3
Poggendorff . .	Amal. zinc	Solution of chromate of potash	"	1.08
"	"	12 parts $K_2Cr_2O_7$ + 25 parts H_2SO_4 + 100 parts H_2O . .	"	2.01
J. Regnault. . .	"	1 part H_2SO_4 + 12 parts H_2O + 1 part $CaSO_4$ . .	Cadmium . . .	0.34
Volta couple . .	Zinc . .	H_2O	Copper	0.98
(c) STANDARD CELLS.				
Kelvin, Gravity, Daniell . . .	Amal. zinc	$ZnSO_4$ solution, density 1.40	Electrolytic copper in $CuSO_4$ sol. density 1.10 . .	1.072 [1 —.00016 (t—15)]
Clark standard .	"	Mercurous sulphate in paste with saturated solution of neutral $ZnSO_4$	Mercury. . . .	1.434 [1 —.00077 (t—15)]
Baille & Ferry .	"	Zinc chloride, density 1.157	Lead surrounded by powdered $PbCl_2$	0.50 temperature coeffic't about .00011
Gouy	"	Oxide of mercury in a 10 % sol. of $ZnSO_4$ (paste)	Mercury. . . .	1.387 [1 —.0002 (t—12)]
Lodge's standard cell and Fleming's standard cell are, like the Kelvin cell above, modifications of the Daniell zinc-zinc sulphate, copper-copper sulphate cell.				
(d) SECONDARY CELLS.				
Faure-Sellon-(Volckmar) .	Lead . .	H_2SO_4 solution of density 1.1 . . .	PbO_2	2.2*
Regnier (1) . .	Copper .	$CuSO_4 + H_2SO_4$ . .	"	1.68 to 0.85, average 1.3.
" (2) . .	Amal. zinc	$ZnSO_4$ solution . . .	" in H_2SO_4 . .	2.36
Main	Amal. zinc	H_2SO_4 density ab't 1.1	"	2.50

* F. Streintz gives the following value of the temperature variation $\frac{dE}{dt}$ at different degrees of charge: —

E. M. F.	$dE/dt \times 10^6$	E. M. F.	$dE/dt \times 10^6$	E. M. F.	$dE/dt \times 10^6$
1.9223	140	2.0031	335	2.0779	130
1.9828	228	2.0084	285	2.2070	73
		2.0105	255		

TABLE 255.

THERMOELECTRIC POWER.

The thermoelectric power of a circuit of two metals at mean temperature t is the electromotive force in the circuit for one degree difference of temperature between the junctions. It is expressed by $dE/dt = A + Bt$, when $dE/dt = 0$, $t = -A/B$, and this the neutral point or temperature at which the thermoelectric power vanishes. The ratio of the specific heat of electricity to the absolute value of the temperature t is expressed by $-B$ for any one metal when the other metal is lead. The thermoelectric power of different couples may be inferred from the table, as it is the difference of the tabulated values with respect to lead, which is here taken as zero. The table has been compiled from the results of Becquerel, Matthieson, and Tait. In reducing the results the electromotive forces of the Grove's and the Daniell cells have been taken as 1.95 and 1.07 volts respectively.

Substance.	A	$B \times 10^{-2}$	Thermoelectric power at mean temp. of junctions (microvolts).		Neutral point $-\frac{A}{B}$	Authority.
			20° C.	50° C.		
Aluminium	0.76	−0.39	0.68	0.56	195	T
Antimony, comm'l pressed wire	–	–	−6.0	–	–	M
" axial	–	–	−22.6	–	–	"
" equatorial	–	–	−26.4	–	–	"
" ordinary	–	–	−17.0	–	–	B
Argentan	11.94	5.06	12.95	14.47	−236	T
"	–	–	–	12.7	–	B
Arsenic	–	–	13.56	–	–	M
Bismuth, comm'l pressed wire	–	–	97.0	–	–	"
" pure " "	–	–	89.0	–	–	"
" crystal, axial	–	–	65.0	–	–	"
" " equatorial	–	–	45.0	–	–	"
" commercial	–	–	–	39.9	–	B
Cadmium	−2.63	−4.24	−3.48	−4.75	−62	T
" fused	–	–	–	−2.45	–	B
Cobalt	–	–	22.	–	–	M
Copper	−1.34	−0.94	−1.52	−1.81	−143	T
" commercial	–	–	−0.10	–	–	M
" galvanoplastic	–	–	−3.8	–	–	"
Gold	–	–	−1.2	–	–	"
"	−2.80	−1.01	−3.0	−3.30	−277	T
Iron	−17.15	4.82	−16.2	−14.74	356	"
" pianoforte wire	–	–	−17.5	–	–	M
" commercial	–	–	–	−12.10	–	B
" "	–	–	–	−9.10	–	"
Lead	–	0.00	0.00	0.00	–	–
Magnesium	−2.22	0.94	−2.03	−1.75	236	T
Mercury	–	–	0.413	–	–	M
"	–	–	–	3.30	–	B
Nickel	–	–	–	15.50	–	"
" (−18° to 175°)	21.8	5.06	22.8	24.33	−438	T
" (250°–300°)	83.57	−23.84	–	–	–	"
" (above 340°)	3.04	5.06	–	–	–	"
Palladium	6.18	3.55	6.9	7.96	−174	"
"	–	–	–	6.9	–	B
Phosphorus (red)	–	–	−29.9	–	–	M
Platinum	–	–	−0.9	–	–	"
" (hardened)	−2.57	0.74	−2.42	−2.20	347	T
" (malleable)	0.60	1.09	8.82	1.15	−55	"
" wire	–	–	–	−0.94	–	B
" another specimen	–	–	–	2.14	–	"
Platinum-iridium alloys:						
85% Pt + 15% Ir	−7.90	−0.62	−8.03	−8.21	−1274	T
90% Pt + 10% Ir	−5.90	1.33	−5.63	−5.23	444	"
95% Pt + 5% Ir	−6.15	−0.55	−6.26	−6.42	−1118	"
Selenium	–	–	−807.	–	–	M
Silver	−2.12	−1.47	−2.41	−2.86	−144	T
" (pure hard)	–	–	−3.00	–	–	M
" wire	–	–	–	−2.18	–	B
Steel	−11.27	3.25	−10.62	−9.65	347	T
Tellurium	–	–	−502.	–	–	M
"	–	–	–	−429.3	–	B
Tin (commercial)	–	–	–	−0.33	–	"
"	–	–	−0.1	–	–	M
"	0.43	−0.55	0.33	0.16	78	T
Zinc	−2.32	−2.38	−2.79	−3.51	−98	"
" pure pressed	–	–	−3.7	–	–	M

B = Ed. Becquerel, "Ann. de Chim. et de Phys" [4] vol 8.
T = Tait, "Trans. R. S. E." vol. 27, reduced by Mascart.
M = Matthieson, "Pogg. Ann." vol. 103, reduced by Fleming Jenkin.

Table 256.

THERMOELECTRIC POWER OF ALLOYS.

The thermoelectric powers of a number of alloys are given in this table, the authority being Ed. Becquerel. They are relative to lead, and for a mean temperature of 50° C. In reducing the results from copper as a reference metal, the thermoelectric power of lead to copper was taken as —1.9.

Substance.	Relative quantity.	Thermo-electric power in microvolts.
Antimony Cadmium	806 696	227
Antimony Cadmium Zinc	4 2 1	146
Antimony Cadmium Bismuth	806 696 121	137
Antimony Zinc	806 406	95
Antimony Zinc Bismuth	806 406 121	8.1
Antimony Cadmium Lead Zinc	4 2 1 1	76
Antimony Cadmium Zinc Tin	4 2 1 1	46
Antimony Zinc Tin	2 1 1	43
Antimony Cadmium Zinc	12 10 3	35
Antimony Tellurium	10 1	10.2

Substance.	Relative quantity.	Thermo-electric power in microvolts.
Antimony Bismuth	10 1	8.8
Antimony Iron	4 1	2.5
Antimony Magnesium	8 1	1.4
Antimony Lead	8 1	—0.4
Bismuth	-	—43.8
Bismuth Antimony	2 1	—33.4
Bismuth Antimony	4 1	—51.4
Bismuth Antimony	8 1	—63.2
Bismuth Antimony	10 1	—68.2
Bismuth Antimony	12 1	—66.9
Bismuth Tin	2 1	6 0
Bismuth Selenium	10 1	—24.5
Bismuth Zinc	12 1	—31.1
Bismuth Arsenic	12 1	—46.0
Bismuth Bismuth sulphide	1 1	68.1

Table 257.

NEUTRAL POINTS WITH LEAD.*

Substance.	Temp. C.	Substance.	Temp. C.
Bismuth	—580°	Zinc	—95°
Nickel	—424	Cadmium	—59
Gold	—276	Platinum	—56
Argentan	—238	Tin	75
Cobalt	—228	Rhodium	132
Palladium	—172	Ruthenium	136
Antimony	—156	Aluminium	212
Silver	—144	Magnesium	239
Copper	—132	Iron	356

Table 258.

SPECIFIC HEATS OF ELECTRICITY.†

The numbers are the coefficients B in the equation $\frac{dE}{dt} = A + Bt$, and have to be multiplied by the absolute temperature T to give the specific heat of electricity. (See also Table 255.)

Metal.	Sp. ht. of el. / T	Metal.	Sp. ht. of el. / T
Aluminium	.00039	Magnesium	—.00094
Antimony	.02221	Nickel:	
Argentan	—.00507	To 175° C.	—.00507
Bismuth	—.01073	250°–310°	.00219
Cadmium	.00425	Above 340°	—.00351
Cobalt	—.01141	Platinum (soft)	—.00109
Copper	.00094	Palladium	—.00355
Gold	.00101	Rhodium	—.00113
Iron	—.00481	Rubidium	—.00206
Iridium	.00000	Silver	.00148
Lead	.00000	Tin	.00055
		Zinc	.00235

* Tait's "Heat," p. 180.

† Calculated from a table given by Tait by assuming the electromotive force of a Grove's cell = 1.95 volts.

TABLE 259.

THERMOELECTRIC POWER OF METALS AND SOLUTIONS.*

Thermoelectric power of circuits, the two parts of which are either a metal and a solution of a salt of that metal or two solutions of salts. The concentration of the solution was such that in 1000 parts of the solution there was one half gramme equivalent of the crystallized salt. The circuit is indicated symbolically; for example, Cu and $CuSO_4$ indicates that the circuit was partly copper and partly a solution of copper sulphate.

Substances forming circuit.	Thermoelectric power in microvolts.
Cu and $CuSO_4$	754
Zn and $ZnSO_4$	760
Cu and CuAc (acetate)	660
Pb and PbAc	176
Zn and ZnAc	693
Cd and CdAc	503
Zn and $ZnCl_2$	562
Cd and $CdCl_2$	562
Zn and $ZnBr_2$	632
Zn and ZnI_2	602
Cd and CdI_2	594
$CuSO_4$ and $ZnSO_4$	40
CuAc and ZnAc	8
ZnAc and CdAc	0
CuAc and CdAc	0
PbAc and ZnAc	73
PbAc and CdAc	54
PbAc and CuAc	133
$ZnCl_2$ and $CdCl_2$	9
$ZnBr_2$ and $CdBr_2$	15
ZnI_2 and CdI_2	82

Insoluble salts mixed with a solution of the corresponding zinc or cadmium salts for the purpose of acting as a conductor. The other part of the circuit was the metal of the insoluble salts. The results are complex and of doubtful value.

Substances forming circuit.	Thermoelectric power in microvolts.
Ag and AgCl in $ZnCl_2$	143
Ag and AgCl in $CdCl_2$	310
Ag and AgBr in $ZnBr_2$	327
Ag and AgBr in $CdBr_2$	461
Ag and AgI in ZnI_2	414
Ag and AgI in CdI_2	unsuccessful
Hg and Hg_2Cl_2 in $ZnCl_2$	680
Hg and Hg_2Cl_2 in $CdCl_2$	673
Hg and Hg_2Br_2 in $ZnBr_2$	650
Hg and Hg_2Br_2 in $CdBr_2$	815
Hg and Hg_2I_2 in ZnI_2	948
Hg and Hg_2I_2 in CdI_2	891

TABLES 260, 261.

PELTIER EFFECT.

TABLE 260.—Jahn's Experiments.†

Current flows from copper to metal mentioned. Table gives therms per ampere per hour.

Metals.	Therms.
Cadmium	—0.616
Iron	—3.613
Nickel	4.362
Platinum	0.320
Silver	—0.413
Zinc	—0.585
Cd to $CdSO_4$	4.29
Cu to $CuSO_4$	—1.4
Ag to $AgNO_3$	7.53
Zn to $ZnSO_4$	—2.14

TABLE 261.—Le Roux's Experiments.‡

Table gives therms per ampere per hour, and current flows from copper to substance named.

Metals.	Therms.
Antimony (Becquerel's) §	13.02
" (commercial)	4.8
Bismuth (pure)	19.1
" (Becquerel's) ‖	25.8
Cadmium	0.46
German silver	2.47
Iron	2.5
Zinc	0.39

* Gockel, "Wied. Ann." vol. 24, p. 634.
† "Wied. Ann." vol. 34, p. 767.
‡ "Ann. de Chim. et de Phys." (4) vol. 10, p. 201.
§ Becquerel's antimony is 806 parts Sb + 406 parts Zn + 121 parts Bi.
‖ Becquerel's bismuth is 10 parts Bi + 1 part Sb.

CONDUCTIVITY OF THREE-METAL AND MISCELLANEOUS ALLOYS.

Conductivity $C_t = C_0(1 + at + bt^2)$.

Metals and alloys.	Composition by weight.	$\frac{C_0}{10^4}$	$a \times 10^6$	$b \times 10^9$	Authority.
Gold-copper-silver . . .	58.3 Au + 26.5 Cu + 15.2 Ag	7.58	574	924	1
" " " . . .	66.5 Au + 15.4 Cu + 18.1 Ag	6.83	529	93	1
" " " . . .	7.4 Au + 78.3 Cu + 14.3 Ag	28.06	1830	7280	1
Nickel-copper-zinc . . .	12.84 Ni + 30.59 Cu + 6.57 Zn by volume . . .	4.92	444	51	1
Brass	Various	12.2–15.6	1–2 × 10³	–	2
" hard drawn . . .	70.2 Cu + 29.8 Zn	12.16	–	–	3
" annealed	" "	14.35	–	–	3
German silver	Various	3–5	–	–	2
" "	60.16 Cu + 25.37 Zn + 14.03 Ni + .30 Fe with trace of cobalt and manganese .	3.33	360	–	4
Aluminium bronze . . .	– – –	7.5–8.5	5–7 × 10²	–	2
Phosphor bronze . . .	– – –	10–20	–	–	2
Silicium bronze	– – –	41	–	–	5
Manganese-copper . . .	30 Mn + 70 Cu	1.00	40	–	4
Nickel-manganese-copper	3 Ni + 24 Mn + 73 Cu . .	2.10	–30	–	4
Nickelin	18.46 Ni + 61.63 Cu + 19.67 Zn + 0.24 Fe + 0.19 Co + 0.18 Mn . . .	3.01	300	–	4
Patent nickel	25.1 Ni + 74.41 Cu + 0.42 Fe + 0.23 Zn + 0.13 Mn + trace of cobalt	2.92	190	–	4
Rheotan	53.28 Cu + 25.31 Ni + 16.89 Zn + 4.46 Fe + 0.37 Mn	1.90	410	–	4
Copper-manganese-iron .	91 Cu + 7.1 Mn + 1.9 Fe .	4.98	120	–	6
" " " .	70.6 Cu + 23.2 Mn + 6.2 Fe	1.30	22	–	6
" " " .	69.7 Cu + 29.9 Ni + 36 Fe .	2.60	120	–	7
				Temp. C.°	
Manganin	84 Cu + 12 Mn + 4 Ni . .	2.33	25	10–20	8
"	" " " . .	"	14	20–30	8
"	" " " . .	"	4	30–35	8
"	" " " . .	"	3	35–40	8
"	" " " . .	"	1	40–45	8
"	" " " . .	"	–1	45–50	8
"	" " " . .	"	–2	50–55	8
"	" " " . .	"	–4	55–68	8

[1] Matthieson. [2] Various. [3] W. Siemens. [4] Feusner and Lindeck. [5] Van der Ven. [6] Blood. [7] Feusner. [8] Lindeck.

TABLE 263.

CONDUCTING POWER OF ALLOYS.

This table shows the conducting power of alloys and the variation of the conducting power with temperature.*

The values of C_0 were obtained from the original results by assuming silver $= \frac{10^6}{1.585}$ mhos. The conductivity is taken as $C_t = C_0\,(1 - at + \beta t^2)$, and the range of temperature was from 0° to 100° C.

The table is arranged in three groups to show (1) that certain metals when melted together produce a solution which has a conductivity equal to the mean of the conductivities of the components, (2) the behavior of those metals alloyed with others, and (3) the behavior of the other metals alloyed together.

It is pointed out that, with a few exceptions, the percentage variation between 0° and 100° can be calculated from the formula $P = P_c\,\frac{l}{l'}$, where l is the observed and l' the calculated conducting power of the mixture at 100° C., and P_c is the calculated mean variation of the metals mixed.

Alloys.	Weight % of first named.	Volume % of first named.	$\frac{C_0}{10^4}$	$a \times 10^8$	$b \times 10^9$	Variation per 100° C. Observed.	Variation per 100° C. Calculated.
GROUP 1.							
Sn_6Pb	77.04	83.96	7.57	3890	8670	30.18	29.67
Sn_4Cd	82.41	83.10	9.18	4080	11870	28.89	30.03
SnZn	78.06	77.71	10.56	3880	8720	30.12	30.16
PbSn	64.13	53.41	6.40	3780	8420	29.41	29.10
$ZnCd_2$	24.76	26.06	16.16	3780	8000	29.86	29.67
$SnCd_4$	23.05	23.50	13.67	3850	9410	29.08	30.25
$CdPb_6$	7.37	10.57	5.78	3500	7270	27.74	27.60
GROUP 2.							
Lead-silver ($Pb_{20}Ag$)	95.05	94.64	5.60	3630	7960	28.24	19.96
Lead-silver (PbAg)	48.97	46.90	8.03	1960	3100	16.53	7.73
Lead-silver ($PbAg_2$)	32.44	30.64	13.80	1990	2600	17.36	10.42
Tin-gold ($Sn_{12}Au$)	77.94	90.32	5.20	3080	6640	24.20	14.83
" " (Sn_5Au)	59.54	79.54	3.03	2920	6300	22.90	5.95
Tin-copper	92.24	93.57	7.59	3680	8130	28.71	19.76
" " †	80.58	83.60	8.05	3330	6840	26.24	14.57
" " †	12.49	14.91	5.57	547	294	5.18	3.99
" " †	10.30	12.35	6.41	666	1185	5.48	4.46
" " †	9.67	11.61	7.64	691	304	6.60	5.22
" " †	4.96	6.02	12.44	995	705	9.25	7.83
" " †	1.15	1.41	39.41	2670	5070	21.74	20.53
Tin-silver	91.30	96.52	7.81	3820	8190	30.00	23.31
" "	53.85	75.51	8.65	3770	8550	29.18	11.89
Zinc-copper †	36.70	42.06	13.75	1370	1340	12.40	11.29
" " †	25.00	29.45	13.70	1270	1240	11.49	10.08
" " †	16.53	23.61	13.44	1880	1800	12.80	12.30
" " †	8.89	10.88	29.61	2040	3030	17.41	17.42
" " †	4.06	5.03	38.09	2470	4100	20.61	20.62

NOTE. — Barus, in the "Am. Jour. of Sci." vol. 36, has pointed out that the temperature variation of platinum alloys containing less than 10% of the other metal can be nearly expressed by an equation $y = \frac{n}{x} - m$, where y is the temperature coefficient and x the specific resistance, m and n being constants. If a be the temperature coefficient at 0° C. and s the corresponding specific resistance, $s\,(a + m) = n$.

For platinum alloys Barus's experiments gave $m = -.000194$ and $n = .0378$.
For steel $m = -.000303$ and $n = .0620$.

Matthieson's experiments reduced by Barus gave for

Gold alloys $m = -.000045$, $n = .00721$.
Silver " $m = -.000112$, $n = .00538$.
Copper " $m = -.000386$, $n = .00055$.

* From the experiments of Matthieson and Vogt, "Phil. Trans. R. S." v. 154.
† Hard-drawn.

CONDUCTING POWER OF ALLOYS.

Alloys.	Weight % of first named.	Volume % of first named.	$\frac{C_0}{10^4}$	$a \times 10^8$	$b \times 10^9$	Variation per 100° C. Observed.	Variation per 100° C. Calculated.
Group 3.							
Gold-copper †	99.23	98.36	35.42	2650	4650	21.87	23.22
" " †	90.55	81.66	10.16	749	81	7.41	7.53
Gold-silver †	87.95	79.86	13.46	1090	793	10.09	9.65
" " *	87.95	79.86	13.61	1140	1160	10.21	9.59
" " †	64.80	52.08	9.48	673	246	6.49	6.58
" " *	64.80	52.08	9.51	721	495	6.71	6.42
" " †	31.33	19.86	13.69	885	531	8.23	8.62
" " *	31.33	19.86	13.73	908	641	8.44	8.31
Gold-copper †	34.83	19.17	12.94	864	570	8.07	8.18
" " †	1.52	0.71	53.02	3320	7300	25.90	25.86
Platinum-silver †	33.33	19.65	4.22	330	208	3.10	3.21
" " †	9.81	5.05	11.38	774	656	7.08	7.25
" " †	5.00	2.51	19.96	1240	1150	11.29	11.88
Palladium-silver †	25.00	23.28	5.38	324	154	3.40	4.21
Copper-silver †	98.08	98.35	56.49	3450	7990	26.50	27.30
" " †	94.40	95.17	51.93	3250	6940	25.57	25.41
" " †	76.74	77.64	44.06	3030	6070	24.29	21.92
" " †	42.75	46.67	47.29	2870	5280	22.75	24.00
" " †	7.14	8.25	50.65	2750	4360	23.17	25.57
" " †	1.31	1.53	50.30	4120	8740	26.51	29.77
Iron-gold †	13.59	27.93	1.73	3490	7010	27.92	14.70
" " †	9.80	21.18	1.26	2970	1220	17.55	11.20
" " †	4.76	10.96	1.46	487	103	3.84	13.40
Iron-copper †	0.40	0.46	24.51	1550	2090	13.44	14.03
Phosphorus-copper †	2.50	-	4.62	476	145	-	-
" " †	0.95	-	14.91	1320	1640	-	-
Arsenic-copper †	5.40	-	3.97	516	989	-	-
" " †	2.80	-	8.12	736	446	-	-
" " †	trace	-	38.52	2640	4830	-	-

* Annealed. † Hard-drawn.

TABLE 264.

SPECIFIC RESISTANCE OF METALLIC WIRES.

This table is modified from the table compiled by Jenkin from Matthieson's results by taking the resistance of silver, gold, and copper from the observed metre gramme value and assuming the densities found by Matthieson, namely, 10.468, 19.265, and 8.95.

Substance.	Resistance at 0° C. of a wire one cm. long, one sq. cm. in section.	Resistance at 0° C. of a wire one metre long, one mm. in diam.	Resistance at 0° C. of a wire one metre long, weighing one gramme.	Resistance at 0° C. of a wire one foot long, 1/1000 in. in diam.	Resistance at 0° C. of a wire one foot long, weighing one grain.	Percentage increase of resistance for 1° C. increase of temp. at 20° C.
Silver annealed . . .	1.460×10^{-6}	0.01859	.1523	8.781	.2184	0.377
" hard drawn . .	1.585 "	0.02019	.1659	9.538	.2379	–
Copper annealed . .	1.584 "	0.02017	.1421	9.529	.2037	0.388
" hard drawn . .	1.619 "	0.02062	.1449	9.741	.2078	–
Gold annealed . . .	2.088 "	0.02659	.4025	12.56	.5771	0.365
" hard drawn . .	2.125 "	0.02706	.4094	12.78	.5870	–
Aluminium annealed . .	2.906 "	0.03699	.0747	17.48	.1071	–
Zinc pressed . . .	5.613 "	0.07146	.4012	33.76	.5753	0.365
Platinum annealed . .	9.035 "	0.1150	1.934	54.35	2.772	–
Iron " . .	9.693 "	0.1234	.7551	58.31	1.083	–
Nickel " . .	12.43 "	0.1583	1.057	74.78	1.515	–
Tin pressed . . .	13.18 "	0.1678	.9608	79.29	1.377	0.365
Lead " . . .	19.14 "	0.2437	2.227	115.1	3.193	0.387
Antimony pressed . .	35.42 "	0.4510	2.379	213.1	3.410	0.389
Bismuth " . .	130.9 "	1.667	12.86	787.5	18.43	0.354
Mercury " . .	94.07 "	1.198	12.79	565.9	18.34	0.072
Platinum-silver, 2 parts Ag, 1 part Pt, by weight .	24.33 "	0.3098	2.919	146.4	4.186	0.031
German silver . . .	20.89 "	0.2660	1.825	125.7	2.617	0.044
Gold-silver, 2 parts Au, 1 part Ag, by weight .	10.84 "	0.1380	1.646	65.21	2.359	0.065

SPECIFIC RESISTANCE OF METALS.

The specific resistance is here given as the resistance, in microhms, per centimetre of a bar one square centimetre in cross section.

Substance.	Physical state.	Specific resistance.	Temp. C.	Authority.
Aluminium	–	2.9–4.5	0	Various.
Antimony .	–	35.4–45.8	0	"
" .	Solid	182.8	Melting-point	De la Rive.
" .	Liquid	129.2	"	"
" .	–	137.7	860	"
Arsenic .	–	33.3	0	Matthieson and Vogt.
Bismuth .	Electrolytic soft	108.0	0	Van Aubel.
" .	" hard	108.7	0	"
" .	Commercial	110–268	0	Various.
Boron . .	Pulverized and compressed	8 × 10^{10}	–	Moissan.
Cadmium .	–	6.2–7.0	–	Various.
" .	Solid	16.5	318	Vassura.
" .	Liquid	37.9	318	"
Gold . .	–	2.04–2.09	0	Various.
Calcium .	–	7.5	16.8	Matthieson.
Cobalt . .	–	9.8	0	"
Copper . .	Commercial	1.58–2.20	0	Various.
Iron . . .	"	9.7–12.0	0	"
" . . .	Electrolytic	11.2	Ordinary	Kohlrausch.
" . . .	"	105.5	Red heat	"
" . . .	"	114.8	Yellow heat	"
" . . .	"	118.3	Iron magnetic heat	"
Steel. . .	Cast	19.1	Ord. temp.	"
" . . .	"	85.8	Red heat	"
" . . .	"	104.4	Yellow heat	"
" . . .	"	113.9	Nearly white heat	"
" . . .	Tempered glass hard	45.7 (1 + .00161*t*)	*t*	Barus and Strouhal.
" . . .	" light yellow	28.9 (1 + .00244*t*)	*t*	" "
" . . .	" yellow	26.3 (1 + .00280*t*)	*t*	" "
" . . .	" blue	20.5 (1 + .00330*t*)	*t*	" "
" . . .	" light blue	18.4 (1 + .00360*t*)	*t*	" "
" . . .	" soft	15.9 (1 + .00423*t*)	*t*	" "
Iron . . .	Cast, hard	97.8	0	" "
" . . .	" soft	74.4	0	" "
Indium . .	–	8.38	0	Erhard.
Lead . .	–	18.4–19.6	0	Various.
Lithium .	–	8.8	20	Matthieson.
Magnesium	–	4.1–5.0	0	Various.
Nickel . .	–	10.7–12.4	0	"
Palladium .	–	10.6–13.6	0	"
Platinum .	–	9.0–15.5	0	"
Potassium .	–	25.1	0	Matthieson.
" .	Fluid	50.4	100	"
Silver . .	–	1.5–1.7	0	Various.
Strontium .	–	25.13	20	Matthieson.
Tellurium .	–	2.17 × 10^5	19.6	"
" .	–	55.05	294	Vincentini and Omodei.
Tin . . .	–	9.53–11.4	0	Various.
" . . .	–	9.53	0	Vassura.
" . . .	Solid	20.96	226.5	"
" . . .	Liquid	44.56	226.5	"
Zinc . . .	–	5.56–6.04	0	–
" . . .	Solid	18.16	Melting-point	De la Rive.
" . . .	Liquid	36.00	"	"

RESISTANCE OF METALS AND

The electrical resistance of some pure metals and of some alloys have been determined by Dewar and Fleming and increases as the temperature is lowered. The resistance seems to approach zero for the pure metals, but not for temperature tried. The following table gives the results of Dewar and Fleming.*

When the temperature is raised above 0° C. the coefficient decreases for the pure metals, as is shown by the experi- experiments to be approximately true, namely, that the resistance of any pure metal is proportional to its absolute is greater the lower the temperature, because the total resistance is smaller. This rule, however, does not even zero Centigrade, as is shown in the tables of resistance of alloys. (Cf. Table 262.)

Temperature =	100°	20°	0°	−80°
Metal or alloy.	Specific resistance in c. g. s. units.			
Aluminium, pure hard-drawn wire	4745	3505	3161	–
Copper, pure electrolytic and annealed	1920	1457	1349	–
Gold, soft wire	2665	2081	1948	1400
Iron, pure soft wire	13970†	9521	8613	–
Nickel, pure (prepared by Mond's process from compound of nickel and carbon monoxide)	19300	13494	12266	7470
Platinum, annealed	10907	8752	8221	6133
Silver, pure wire	2139	1647	1559	1138
Tin, pure wire	13867	10473	9575	6681
German silver, commercial wire	35720	34707	34524	33664
Palladium-silver, 20 Pd + 80 Ag	15410	14984	14961	14482
Phosphor-bronze, commercial wire	9071	8588	8479	8054
Platinoid, Martino's platinoid with 1 to 2% tungsten	44590	43823	43601	43022
Platinum-iridium, 80 Pt + 20 Ir	31848	29902	29374	27504
Platinum-rhodium, 90 Pt + 10 Rh	18417	14586	13755	10778
Platinum-silver, 66.7 Ag + 33.3 Pt	27404	26915	26818	26311
Carbon, from Edison-Swan incandescent lamp	–	4046×10^8	4092×10^8	4189×10^8
Carbon, from Edison-Swan incandescent lamp	3834×10^8	3908×10^8	3955×10^8	4054×10^8
Carbon, adamantine, from Woodhouse and Rawson incandescent lamp	6168×10^8	6300×10^8	6363×10^8	6495×10^8

* "Phil. Mag." vol. 34, 1892.

† This is given by Dewar and Fleming as 13777 for 96°.4, which appears from the other measurements too high.

ALLOYS AT LOW TEMPERATURES.

by Cailletet and Bouty at very low temperatures. The results show that the coefficient of change with temperature the alloys. The resistance of carbon was found by Dewar and Fleming to increase continuously to the lowest

ments or Müller, Benoit, and others. Probably the simplest rule is that suggested by Clausius, and shown by these temperature. This gives the actual change of resistance per degree, a constant; and hence the percentage of change approximately hold for alloys, some of which have a negative temperature coefficient at temperatures not far from

Temperature =	−100°	−182°	−197°	Mean value of temperature coefficient between −100° and +100° C.*
Metal or alloy.	Specific resistance in c. g. s. units.			
Aluminium, pure hard-drawn wire	1928	894	–	.00446
Copper, pure electrolytic and annealed	757	272	178	431
Gold, soft wire	1207	604	–	375
Iron, pure soft wire	4010	1067	608	578
Nickel, pure (prepared by Mond's process from compound of nickel and carbon monoxide)	6110	1900	–	538
Platinum, annealed	5295	2821	2290	341
Silver, pure wire	962	472	–	377
Tin, pure wire	5671	2553	–	428
German silver, commercial wire	33280	32512	–	035
Palladium-silver, 20 Pd + 80 Ag	14256	13797	–	039
Phosphor-bronze, commercial wire	7883	7371	–	070
Platinoid, Martino's platinoid with 1 to 2% tungsten	42385	41454	–	025
Platinum-iridium, 80 Pt + 20 Ir	26712	24440	–	087
Platinum-rhodium, 90 Pt + 10 Rh	9834	7134	–	312
Platinum-silver, 66.7 Ag + 33.3 Pt	26108	25537	–	024
Carbon, from Edison-Swan incandescent lamp	4218×10^8	4321×10^8	–	–
Carbon, from Edison-Swan incandescent lamp	4079×10^8	4180×10^8	–	031
Carbon, adamantine, from Woodhouse and Rawson incandescent lamp	6533×10^8	–	–	029

* This is α in the equation $R = R_0(1 + \alpha t)$, as calculated from the equation $\alpha = \frac{R_{100} - R_{-100}}{200\,R_0}$.

TABLE 267.

EFFECT OF ELONGATION ON THE SPECIFIC RESISTANCE OF SOFT METALLIC WIRES.*

Substance.	Increase of specific resistance for 1 % of elongation — Permanent elongation.	Elastic elongation.
Copper	From .50 % to .60 %	From 2.5 % to 7.7 %
Iron	" .70 " " .80 "	" 4.6 " " 4.8 "
German silver	" .50 " " .55 "	" 0.7 " " 1.0 "

TABLE 268.

EFFECT OF ALTERNATING THE CURRENT ON ELECTRIC RESISTANCE.

This table gives the percentage increase of the ordinary resistance of conductors of different diameters when the current passing through them alternates with the periods stated in the last column.†

Diameter in — Millimetres.	Inches.	Area in — Sq. mm.	Sq. in.	Percentage increase of ordinary resistance.	Number of complete periods per second.
10	.3937	78.54	.122	Less than $\frac{1}{10}$	80
15	.5905	176.7	.274	2.5	
20	.7874	314.16	.487	8	
25	.9842	490.8	.760	17.5	
40	1.575	1256	1.95	68	
100	3.937	7854	12.17	3.8 times	
1000	39.39	785400	1217	35 times	
9	.3543	63.62	.098	Less than $\frac{1}{100}$	100
13.4	.5280	141.3	.218	2.5	
18	.7086	254.4	.394	8	
22.4	.8826	394	.611	17.5	
7.75	.3013	47.2	.071	Less than $\frac{1}{100}$	133
11.61	.4570	106	.164	2.5	
15.5	.6102	189	.292	8	
19.36	.7622	294	.456	17.5	

* T. Gray, "Trans. Roy. Soc. Edin." 1880.
† W. M. Mordey, "Inst. El. Eng. London," 1889.

CONDUCTIVITY OF ELECTROLYTIC SOLUTIONS.

This subject has occupied the attention of a considerable number of eminent workers in molecular physics, and a few results are here tabulated. It has seemed better to confine the examples to the work of one experimenter, and the tables are quoted from a paper by F. Kohlrausch,* who has been one of the most reliable and successful workers in this field.

The study of electrolytic conductivity, especially in the case of very dilute solutions, has furnished material for generalizations, which may to some extent help in the formation of a sound theory of the mechanism of such conduction. If the solutions are made such that per unit volume of the solvent medium there are contained amounts of the salt proportional to its electrochemical equivalent, some simple relations become apparent. The solutions used by Kohlrausch were therefore made by taking numbers of grammes of the pure salts proportional to their electrochemical equivalent, and using a litre of water as the standard quantity of the solvent. Taking the electrochemical equivalent number as the chemical equivalent or atomic weight divided by the valence, and using this number of grammes to the litre of water, we get what is called the normal or gramme molecule per litre solution. In the table, m is used to represent the number of gramme molecules to the litre of water in the solution for which the conductivities are tabulated. The conductivities were obtained by measuring the resistance of a cell filled with the solution by means of a Wheatstone bridge alternating current and telephone arrangement. The results are for 18° C., and relative to mercury at 0° C., the cell having been standardized by filling with mercury and measuring the resistance. They are supposed to be accurate to within one per cent of the true value.

The tabular numbers were obtained from the measurements in the following manner:—

Let K_{18} = conductivity of the solution at 18° C. relative to mercury at 0° C.

K^w_{18} = conductivity of the solvent water at 18° C. relative to mercury at 0° C.

Then $K_{18} - K^w_{18} = k_{18}$ = conductivity of the electrolyte in the solution measured.

$\frac{k_{18}}{m} = \mu$ = conductivity of the electrolyte in the solution per molecule, or the "specific molecular conductivity."

TABLE 269.—Value of k_{18} for a few Electrolytes.

This short table illustrates the apparent law that the conductivity in very dilute solutions is proportional to the amount of salt dissolved.

m	KCl	NaCl	$AgNO_3$	$KC_2H_3O_2$	K_2SO_4	$MgSO_4$
0.000001	1.216	1.024	1.080	0.939	1.275	1.056
0.00002	2.434	2.056	2.146	1.886	2.532	2.104
0.00006	7.272	6.162	6.462	5.610	7.524	6.216
0.0001	12.09	10.29	10.78	9.34	12.49	10.34

TABLE 270.—Electro-Chemical Equivalents and Normal Solutions.

The following table of the electro-chemical equivalent numbers and the densities of approximately normal solutions of the salts quoted in Table 271 may be convenient. They represent grammes per cubic centimetre of the solution at the temperature given.

Salt dissolved.	Grammes per litre.	m	Temp. C.	Density.	Salt dissolved.	Grammes per litre.	m	Temp. C.	Density.
KCl . . .	74.59	1.0	15.2	1.0457	$\frac{1}{2}K_2SO_4$.	87.16	1.0	18.9	1.0658
NH_4Cl . .	53.55	1.0009	18.6	1.0152	$\frac{1}{2}Na_2SO_4$.	71.09	1.0003	18.6	1.0602
NaCl . . .	58.50	1.0	18.4	1.0391	$\frac{1}{2}Li_2SO_4$.	55.09	1.0007	18.6	1.0445
LiCl . . .	42.48	1.0	18.4	1.0227	$\frac{1}{2}MgSO_4$.	60.17	1.0023	18.6	1.0573
$\frac{1}{2}BaCl_2$ . .	104.0	1.0	18.6	1.0888	$\frac{1}{2}ZnSO_4$.	80.58	1.0	5.3	1.0794
$\frac{1}{2}ZnCl_2$ . .	68.0	1.012	15.0	1.0592	$\frac{1}{2}CuSO_4$.	79.9	1.001	18.2	1.0776
KI	165.9	1.0	18.6	1.1183	$\frac{1}{2}K_2CO_3$.	69.17	1.0006	18.3	1.0576
KNO_3 . .	101.17	1.0	18.6	1.0601	$\frac{1}{2}Na_2CO_3$.	53.04	1.0	17.9	1.0517
$NaNO_3$ . .	85.08	1.0	18.7	1.0542	KOH . .	56.27	1.0025	18.8	1.0477
$AgNO_3$ . .	169.9	1.0	–	–	HCl . .	36.51	1.0041	18.6	1.0161
$\frac{1}{2}Ba(NO_3)_2$.	65.28	0.5	–	–	HNO_3 . .	63.13	1.0014	18.6	1.0318
$KClO_3$ . .	61.29	0.5	18.3	1.0367	$\frac{1}{2}H_2SO_4$.	49.06	1.0006	18.9	1.0300
$KC_2H_3O_2$.	98.18	1.0005	18.6	1.0467					

* "Wied. Ann." vol. 26, pp. 161–226.

TABLE 271.

SPECIFIC MOLECULAR CONDUCTIVITY μ : MERCURY $= 10^8$.

Salt dissolved.	$m=10$	5	3	1	0.5	0.1	.05	.03	.01
$\frac{1}{2}K_2SO_4$	–	–	–	–	672	736	897	959	1098
KCl	–	–	827	919	958	1047	1083	1107	1147
KI	–	770	900	968	997	1069	1102	1123	1161
NH_4Cl	–	752	825	907	948	1035	1078	1101	1142
KNO_3	–	–	572	752	839	983	1037	1067	1122
$\frac{1}{2}BaCl_2$	–	–	487	658	725	861	904	939	1006
$KClO_3$	–	–	–	–	799	927	(976)	1006	1053
$\frac{1}{2}Ba_2N_2O_6$	–	–	–	–	531	755	828	(870)	951
$\frac{1}{2}CuSO_4$	–	–	150	241	288	424	479	537	675
$AgNO_3$	–	351	448	635	728	886	936	(966)	1017
$\frac{1}{2}ZnSO_4$	–	82	146	249	302	431	500	556	685
$\frac{1}{2}MgSO_4$	–	82	151	270	330	474	532	587	715
$\frac{1}{2}Na_2SO_4$	–	–	–	475	559	734	784	828	906
$\frac{1}{2}ZnCl_2$	60	180	280	514	601	768	817	851	915
$NaCl$	–	398	528	695	757	865	897	(920)	962
$NaNO_3$	–	–	430	617	694	817	855	877	907
$KC_2H_3O_2$	30	240	381	594	671	784	820	841	879
$\frac{1}{2}Na_2CO_3$	–	–	254	427	510	682	751	799	899
$\frac{1}{2}H_2SO_4$	660	1270	1560	1820	1899	2084	2343	2515	2855
C_2H_4O	0.5	2.6	5.2	12	19	43	62	79	132
HCl	600	1420	2010	2780	3017	3244	3330	3369	3416
HNO_3	610	1470	2070	2770	2991	3225	3289	3328	3395
$\frac{1}{2}H_3PO_4$	148	160	170	200	250	430	540	620	790
KOH	423	990	1314	1718	1841	1986	2045	2078	2124
NH_3	0.5	2.4	3.3	8.4	12	31	43	50	92

Salt dissolved.	.006	.002	.001	.0006	.0002	.0001	.00006	.00002	.00001
$\frac{1}{2}K_2SO_4$	1130	1181	1207	1220	1241	1249	1254	1266	1275
KCl	1162	1185	1193	1199	1209	1209	1212	1217	1216
KI	1176	1197	1203	1209	1214	1216	1216	1216	1207
NH_4Cl	1157	1180	1190	1197	1204	1209	1215	1209	1205
KNO_3	1140	1173	1180	1190	1199	1207	1220	1198	1215
$\frac{1}{2}BaCl_2$	1031	1074	1092	1102	1118	1126	1133	1144	1142
$KClO_3$	1068	1091	1101	1109	1119	1122	1126	1135	1141
$\frac{1}{2}Ba_2N_2O_6$	982	1033	1054	1066	1084	1096	1100	1114	1114
$\frac{1}{2}CuSO_4$	740	873	950	987	1039	1062	1074	1084	1086
$AgNO_3$	1033	1057	1068	1069	1077	1078	1077	1073	1080
$\frac{1}{2}ZnSO_4$	744	861	919	953	1001	1023	1032	1047	1060
$\frac{1}{2}MgSO_4$	773	881	935	967	1015	1034	1036	1052	1056
$\frac{1}{2}Na_2SO_4$	933	980	998	1009	1026	1034	1038	1056	1054
$\frac{1}{2}ZnCl_2$	939	979	994	1004	1020	1029	1031	1035	1036
$NaCl$	976	998	1008	1014	1018	1029	1027	1028	1024
$NaNO_3$	921	942	952	956	966	975	970	972	975
$KC_2H_3O_2$	891	913	919	923	933	934	935	943	939
$\frac{1}{2}Na_2CO_3$	956	1010	1037	1046	988	874	790	715	697*
$\frac{1}{2}H_2SO_4$	3001	3240	3316	3342	3280	3118	2927	2077	1413*
C_2H_4O	170	283	380	470	796	995	1133	1328	1304*
HCl	3438	3455	3455	3440	3340	3170	2968	2057	1254*
HNO_3	3421	3448	3427	3408	3285	3088	2863	1904	1144*
$\frac{1}{2}H_3PO_4$	858	945	968	977	920	837	746	497	402*
KOH	2141	2140	2110	2074	1892	1689	1474	845	747*
NH_3	116	190	260	330	500	610	690	700	560*

* Acids and alkaline salts show peculiar irregularities.

LIMITING VALUES OF μ.

This table shows limiting values of $\mu = \frac{k}{m} . 10^8$ for infinite dilution for neutral salts, calculated from Table 271.

Salt.	μ	Salt.	μ	Salt.	μ	Salt.	μ
$\frac{1}{2}K_2SO_4$.	1280	$\frac{1}{2}BaCl_2$.	1150	$\frac{1}{2}MgSO_4$.	1080	$\frac{1}{2}H_2SO_4$.	3700
KCl . . .	1220	$\frac{1}{2}KClO_3$.	1150	$\frac{1}{2}Na_2SO_4$.	1060	HCl . .	3500
KI . . .	1220	$\frac{1}{2}BaN_2O_6$.	1120	$\frac{1}{2}ZnCl$ . .	1040	HNO_3 . .	3500
NH_4Cl . .	1210	$\frac{1}{2}CuSO_4$.	1100	NaCl . .	1030	$\frac{1}{3}H_3PO_4$.	1100
KNO_3 . .	1210	$AgNO_3$.	1090	$NaNO_3$.	980	KOH . .	2200
–	–	$\frac{1}{2}ZnSO_4$.	1080	$K_2C_2H_3O_2$	940	$\frac{1}{2}Na_2CO_3$.	1400

If the quantities in Table 271 be represented by curves, it appears that the values of the specific molecular conductivities tend toward a limiting value as the solution is made more and more dilute. Although these values are of the same order of magnitude, they are not equal, but depend on the nature of both the ions forming the electrolyte.

When the numbers in Table 272 are multiplied by Hittorf's constant, or 0.00011, quantities ranging between 0.14 and 0.10 are obtained which represent the velocities in millimetres per second of the ions when the electromotive force gradient is one volt per millimetre.

Specific molecular conductivities in general become less as the concentration is increased, which may be due to mutual interference. The decrease is not the same for different salts, but becomes much more rapid in salts of high valence.

Salts having acid or alkaline reactions show marked differences. They have small specific molecular conductivity in very dilute solutions, but as the concentration is increased the conductivity rises, reaches a maximum and again falls off. Kohlrausch does not believe that this can be explained by impurities. H_3PO_4 in dilute solution seems to approach a monobasic acid, while H_2SO_4 shows two maxima, and like H_3PO_4 approaches in very weak solution to a monobasic acid.

Kohlrausch concludes that the law of independent migration of the ions in media like water is sustained.

TEMPERATURE COEFFICIENT.

The temperature coefficient in general diminishes with dilution, and for very dilute solutions appears to approach a common value. The following table gives the temperature coefficient for solutions containing 0.01 gramme molecule of the salt.

Salt.	Temp. Coeff.	Salt.	Temp. Coeff.	Salt.	Temp. Coeff.	Salt.	Temp. Coeff.
KCl . . .	0.0221	KI . . .	0.0219	$\frac{1}{2}K_2SO_4$.	0.0223	$\frac{1}{2}K_2CO_3$ . .	0.0249
NH_4Cl . .	0.0226	KNO_3 . .	0.0216	$\frac{1}{2}Na_2SO_4$.	0.0240	$\frac{1}{2}Na_2CO_3$ . .	0.0265
NaCl . .	0.0238	$NaNO_3$ . .	0.0226	$\frac{1}{2}Li_2SO_4$.	0.0242	KOH . . .	0.0194
LiCl . . .	0.0232	$AgNO_3$ . .	0.0221	$\frac{1}{2}MgSO_4$.	0.0236	HCl . . .	0.0159
$\frac{1}{2}BaCl_2$ . .	0.0234	$\frac{1}{2}Ba(NO_3)_2$	0.0224	$\frac{1}{2}ZnSO_3$.	0.0234	HNO_3 . . .	0.0162
$\frac{1}{2}ZnCl_2$ . .	0.0239	$KClO_3$ . .	0.0219	$\frac{1}{2}CuSO_4$.	0.0229	$\frac{1}{2}H_2SO_4$ . .	0.0125
$\frac{1}{2}MgCl_2$.	0.0241	$KC_2H_3O_2$.	0.0229	–	–	$\frac{1}{2}H_2SO_4$ for $m = .001$	0.0159

TABLE 274.

VARIOUS DETERMINATIONS OF THE VALUE OF THE OHM, ETC.*

	Observer.	Date.	Method.	Value of B. A. U. in ohms.	Value of 100 cms. of Hg in B. A. U.	Value of ohm in cms. of Hg.
1	Lord Rayleigh	1882	Rotating coil	.98651	(.95412)	106.31
2	Lord Rayleigh	1883	Lorenz method	.98677	–	106.27
3	Mascart	1884	Induced current	.98611	.95374	106.33
4	Rowland	1887	Mean of several methods	.98644	.95349	106.32
5	Kohlrausch	1887	Damping of magnets	.98660	.95338	106.32
6	Glazebrook	1882 to 1888	Induced currents	.98665	.95352	106.29
7	Wuilleumeier	1890	———	.98686	.95355	106.31
8	Duncan & Wilkes	1890	Lorenz method	.98634	.95341	106.34
9	Jones	1891	Lorenz method	–	–	106.31
			Mean	.98653		106.31
10	Strecker	1885	An absolute determination of resistance was not made. The value .98656 has been used.	–	.95334	106.32
11	Hutchinson	1888		–	.95352	106.30
12	Salvioni	1890		–	.95332	106.33
12	Salvioni	–		–	.95354	106.30
			Mean		.95354	106.31
13	H. F. Weber	1884	Induced current	Absolute measurements compared with German silver wire coils issued by Siemens or Strecker.		105.37
14	H. F. Weber	–	Rotating coil			106.16
15	Roti	1884	Mean effect of induced current			105.89
16	Heinstedt	1885	———			105.98
17	Dorn	1889	Damping of magnet			106.24
18	Wild	1883	Damping of magnet			106.03
19	Lorenz	1885	Lorenz method			105.93

The Board of Trade committee recommended for adoption the values .9866 and 106.3. The specific resistance of mercury in ohms is thus $.9407 \times 10^{-4}$.

Also 1 Siemens unit = .9407 ohm.
= .9535 B. A. U.
1 ohm . . . = 1.01358 B. A. U.

The following values have been found for the mass of silver deposited from a solution of silver nitrate in one second by a current of one ampere: —

Mascart, "J. de Physique," iii. 1884	.0011156
Rayleigh, "Phil. Trans." ii. 1884	.0011179
Kohlrausch, "Wied. Ann." xxvii. 1886	.0011183
T. Gray, "Phil. Mag." xxii. 1886	about † .001118
Portier et Pellat, "J. de Physique," ix. 1890	.0011192

The following values have been found for the electromotive force of a Clark cell at 15° C. They have been reduced from those given in the original papers on the supposition that 1 B. A. U. = .9866 ohm, and that the mass of silver deposited per second per ampere is .001118 gramme.

Rayleigh, "Trans." ii. 1884	1.4345 v lt.
Carhart	1.4340 "
Kohle, "Zeitschrift für Instrumentenkunde," 1892	1.4341 "
Glazebrook and Skinner, "Proc. R. S." li. 1892	1.4342 "

* Abstract from the Report of the British Association Committee on Practical Standards for Electrical Measurement, "Proc. Brit. Assoc." 1892.
† ± .0000002 T. G.

SPECIFIC INDUCTIVE CAPACITY OF GASES.

With the exception of the results given by Ayrton and Perry, for which no temperature record has been found, the values are for 0° C. and 760 mm. pressure.

Gas.	Sp. ind. cap.		Authority.
	Vacuum = 1.	Air = 1.	
Air	1.0015	1.0000	Ayrton and Perry.
"	1.00059	1.0000	Klemenčič.
"	1.00059	1.0000	Boltzmann.
Carbon disulphide	1.0029	1.0023	Klemenčič.
Carbon dioxide, CO_2	1.0023	1.0008	Ayrton and Perry.
" " "	1.00098	1.00039	Klemenčič.
" " "	1.00095	1.00036	Boltzmann.
Carbon monoxide, CO	1.00069	1.00010	Klemenčič.
" "	1.00069	1.00010	Boltzmann.
Coal gas (illuminating) . . .	1.0019	1.0004	Ayrton and Perry.
Hydrogen	1.0013	0.9998	Ayrton and Perry.
"	1.00026	0.99967	Klemenčič.
"	1.00026	0.99967	Boltzmann.
Nitrous oxide, N_2O	1.00116	1.00057	Klemenčič.
" " "	1.00099	1.00040	Boltzmann.
Sulphur dioxide	1.0052	1.0037	Ayrton and Perry.
" "	1.00955	1.00896	Klemenčič.
Vacuum 5 mm. pressure . . .	1.0000	0.9985	Ayrton and Perry.
" 0.001 " " about . .	1.0000	0.94	Ayrton and Perry.
"	1.0000	0.99941	Klemenčič.
"	1.0000	0.99941	Boltzmann.

o

TABLE 276.

SPECIFIC INDUCTIVE CAPACITY OF SOLIDS (AIR = UNITY).

Substance.	Sp. ind. cap.	Authority.
Calcspar parallel to axis	7.5	Romich and Nowak.*
" perpendicular to axis	7.7	" " "
Caoutchouc	2.12–2.34	Schiller.
" vulcanized	2.69–2.94	"
Celluvert, hard gray	1.19	Elsas.
" " red	1.44	"
" " black	1.89	"
" soft red	2.66	"
Ebonite	2.08	Rossetti.
"	3.15–3.48	Boltzmann.
"	2.21–2.76	Schiller.
"	2.72	Winkelmann.
"	2.56	Wüllner.
"	2.86	Elsas.
"	1.9	Thomson (from Hertz's vibrations).
Fluor spar	6.7	Romich and Nowak.
" "	6.8	Curie.
Glass,* density 2.5 to 4.5	5–10	Various.
Double extra dense flint, density 4.5	9.90	Hopkinson.
Dense flint, density 3.66	7.38	"
Light flint, " 3.20	6.70	"
Very light flint " 2.87	6.61	"
Hard crown " 2.485	6.96	"
Plate " –	8.45	"
Mirror	5.8–6.34	Schiller.
"	6.46–7.57	Winkelmann.
"	6.88	Donle.
"	6.44–7.46	Elsas.
Plate	3.31–4.12	Schiller.
"	7.5	Romich and Nowak.
"	6.10	Wüllner.
Guttapercha	3.3–4.9	Submarine cable data.
Gypsum	6.33	Curie.
Mica	6.64	Klemenčič.
"	8.00	Curie.
"	7.98	Bouty.
"	5.66–5.97	Elsas.
"	4.6	Romich and Nowak.
Paraffin	2.32	Boltzmann.
"	1.98	Gibson and Barclay.
"	2.29	Hopkinson.
" quickly cooled translucent	1.68–1.92	Schiller.†
" slowly cooled white	1.85–2.47	"
"	2.18	Winkelmann.
"	1.96–2.29	Donle, Wüllner.
" fluid — pasty	1.98–2.08	Arons and Rubens.
" solid	1.95	" " "
Porcelain	4.38	Curie.
Quartz, along the optic axis	4.55	"
" transverse	4.49	"
Resin	2.48–2.57	Boltzmann.
Rock salt	18.0	Hopkinson.
" "	5.85	Curie.
Selenium	10.2	Romich and Nowak.
Shellac	3.10	Winkelmann.
"	3.67	Donle.
"	2.95–3.73	Wüllner.

* The values here quoted apply when the duration of charge lies between 0.25 and 0.00005 of a second. J. J. Thomson has obtained the value 2.7 when the duration of the charge is about $1/25 \times 10^6$ of a second; and this is confirmed by Blondlot, who obtained for a similar duration 2.8.

† The lower values were obtained by electric oscillations of duration of charge about 0.0006 second. The larger values were obtained when duration of charge was about 0.02 second.

SPECIFIC INDUCTIVE CAPACITY OF SOLIDS (AIR = UNITY).

Substance.	Sp. ind. cap.	Authority.
Spermaceti	2.18	Rossetti.
"	2.25	Felici.
Sulphur	3.84–3.90	Boltzmann.
"	2.88–3.21	Wüllner.
"	2.24	J. J. Thomson.
"	2.94	Blondlot.
"	2.56	Trouton and Lilly.

SPECIFIC INDUCTIVE CAPACITY OF LIQUIDS.

Substance.	Sp. ind. cap.	Authority.
Alcohols:		
Amyl	15–15.9	Cohn and Arons; Tereschin.
Ethyl	24–27	Various.
Methyl	32.65	Tereschin.
Propyl	22.8	"
Anilin	7.5	"
Benzene	1.93–2.45	Various.
" average about	2.3	
" at 5° C.	2.1898	Negreano.
" " 15° C.	2.1534	"
" " 25° C.	2.1279	"
" " 40° C.	2.1103	"
Hexane, between 11° and 13° C.	1.859	Landolt and Jahn.
Octane, " 13°.5–14° C.	1.934	" "
Decane, " 13°.5–14°.2 C.	1.966	" "
Amylene, " 15°–16°.2 C.	2.201	" "
Octylene, " 11°.5–13°.6 C.	2.175	" "
Decylene, " 16°.7 C.	2.236	" "
Oils:		
Arachid	3.17	Hopkinson.
Castor	4.6–4.8	Various.
Colza	3.07–3.14	Hopkinson.
Lemon	2.25	Tomaszewski.
Neatsfoot	3.07	Hopkinson.
Olive	3.08–3.16	Arons and Rubens; Hopkinson.
Petroleum	2.02–2.19	Various.
Petroleum ether	1.92	Hopkinson.
Rape-seed	2.2–3.0	Various.
Sesame	3.17	Hopkinson.
Sperm	3.02–3.09	Hopkinson; Rosa.
Turpentine	2.15–2.28	Various.
Vaseline	2.17	Fuchs.
Ozokerite	2.13	Hopkinson.
Toluene	2.2–2.4	Various.
Xylene	2.3–2.6	"

CONTACT DIFFERENCE OF

Solids with Liquids and

Temperature of substances

	Carbon.	Copper.	Iron.	Lead.	Platinum.	Tin.	Zinc.
Mercury	.092	.308	.502	-	.156	-	-
Distilled water	.01 to .17	.269 to .100	.148	.171	.285 to .345	.177	—.105 to +.156
Alum solution: saturated at 16°.5 C.	-	—.127	—.653	—.139	.246	—.225	—.536
Copper sulphate solution: sp. gr. 1.087 at 16°.6 C.	-	.103	-	-	-	-	-
Copper sulphate solution: saturated at 15° C.	-	.070	-	-	-	-	-
Sea salt solution: sp. gr. 1.18 at 20°.5 C.	-	—.475	—.605	-	—.856	—.334	—.565
Sal-ammoniac solution: saturated at 15°.5 C.	-	—.396	—.652	—.189	.059	—.364	—.637
Zinc sulphate solution: sp. gr. 1.125 at 16°.9 C.	-	-	-	-	-	-	—.238
Zinc sulphate solution: saturated at 15°.3 C.	-	-	-	-	-	-	—.430
One part distilled water + 3 parts saturated zinc sulphate solution	-	-	-	-	-	-	—.444
Strong sulphuric acid in distilled water:							
1 to 20 by weight	-	-	-	-	-	-	—.344
1 to 10 by volume	about —.035	-	-	-	-	-	-
1 to 5 by weight	-	-	-	-	-	-	-
5 to 1 by weight	.01 to 3.0	-	-	—.120	-	—.25	-
Concentrated sulphuric acid	.55 to .85	1.113	-	.72 to 1.252	1.3 to 1.6	-	-
Concentrated nitric acid	-	-	-	-	.672	-	-
Mercurous sulphate paste	-	-	-	-	-	-	-
Distilled water containing trace of sulphuric acid	-	-	-	-	-	-	—.241

* Everett's "Units and Physical Constants:" Table of

POTENTIAL IN VOLTS.

Liquids with Liquids in Air.*

during experiment about 16° C.

	Amalgamated zinc.	Brass.	Mercury.	Distilled water.	Alum solution: saturated at 16°.5 C.	Copper sulphate solution: saturated at 15° C.	Zinc sulphate solution: sp. gr. 1.25 at 16°.9 C.	Zinc sulphate solution: saturated at 15°.3 C.	One part distilled water + 3 pts. zinc sulphate.	Strong nitric acid.
Mercury	-	-	-	-	-	-	-	-	-	-
Distilled water	.100	.231	-	-	-	—.043	-	.164	-	-
Alum solution: saturated at 16°.5 C.	-	—.014	-	-	-	-	-	-	-	-
Copper sulphate solution: sp. gr. 1.087 at 16°.6 C.	-	-	-	-	-	-	.090	-	-	-
Copper sulphate solution: saturated at 15° C. . .	-	-	-	—.043	-	-	-	.095	.102	-
Sea salt solution: sp. gr. 1.18 at 20°.5 C. . . .	-	—.435	-	-	-	-	-	-	-	-
Sal-ammoniac solution: saturated at 15°.5 C. .	-	—.348	-	-	-	-	-	-	-	-
Zinc sulphate solution: sp. gr. 1.125 at 16°.9 C.	-	-	-	-	-	-	-	-	-	-
Zinc sulphate solution: saturated at 15°.3 C. .	—.284	-	-	—.200	-	—.095	-	-	-	-
One part distilled water + 3 parts saturated zinc sulphate solution . .	-	-	-	-	-	—.102	-	-	-	-
Strong sulphuric acid in distilled water:										
1 to 20 by weight . . .	-	-	-	-	-	-	-	-	-	-
1 to 10 by volume . . .	—.358	-	-	-	-	-	-	-	-	-
1 to 5 by weight	.429	-	-	-	-	-	-	-	-	-
5 to 1 by weight	-	—.016	-	-	-	-	-	-	-	-
Concentrated sulphuric acid	.848	-	-	1.298	1.456	1.269	-	1.699	-	-
Concentrated nitric acid .			-	-	-	-	-	-	-	-
Mercurous sulphate paste .	-	-	.475	-	-	-	-	-	-	-
Distilled water containing trace of sulphuric acid .	-	-	-	-	-	-	-	-	-	.078

Ayrton and Perry's results, prepared by Ayrton.

TABLE 279.

CONTACT DIFFERENCE OF POTENTIAL IN VOLTS.

Solids with Solids in Air.*

Temperature of substances during the experiment about 18° C.

	Carbon.	Copper.	Iron.	Lead.	Platinum.	Tin.	Zinc.	Zinc amalgam.	Brass.
Carbon . . .	0	.370	.485	.858	.113	.795	1.096†	1.208†	.414†
Copper . . .	—.370	0	.146	.542	—.238	.456	.750	.894	.087
Iron	—.485†	—.146	0	.401†	—.369	.313†	.600†	.744†	—.064
Lead . . .	—.858	—.542	—.401	0	—.771	—.099	.210	.357†	—.472
Platinum . .	—.113†	.238	.369	.771	0	.690	.981	1.125†	.287
Tin	—.795†	—.458	—.313	.099	—.690	0	.281	.463	—.372
Zinc	—1.096†	—.750	—.600	—.216	—.981	.281	0	.144	—.679
" amalgam	—1.208†	—.894	—.744	—.357†	—1.125†	—.463	—.144	0	—.822
Brass . . .	—.414	—.087	.064	.472	—.287	.372	.679	.822	0

The numbers not marked were obtained by direct experiment, those marked with a dagger by calculation, on the assumption that in a compound circuit of metals, all at the same temperature, there is no electromotive force.

The numbers in the same vertical column are the differences of potential in volts between the substance named at the top of the column and the substance named on the same line in the first column, when the two substances are in contact.

The metals used were those ordinarily obtained in commerce.

* Everett's "Units and Physical Constants." The table is from Ayrton and Perry's experiments, and was prepared by Ayrton.

DIFFERENCE OF POTENTIAL BETWEEN METALS IN SOLUTIONS OF SALTS.

The following numbers are given by G. Magnanini * for the difference of potential in hundredths of a volt between zinc in a normal solution of sulphuric acid and the metals named at the head of the different columns when placed in the solution named in the first column. The solutions were contained in a U-tube, and the sign of the difference of potential is such that the current will flow from the more positive to the less positive through the external circuit.

Strength of the solution in gramme molecules per litre.		Zinc.†	Cadmium.†	Lead.	Tin.	Copper.	Silver.
No. of molecules.	Salt.	Difference of potential in centivolts.					
0.5	H_2SO_4	0.0	36.6	51.3	51.3	100.7	121.3
1.0	NaOH	—32.1	19.5	31.8	0.2	80.2	95.8
1.0	KOH	—42.5	15.5	32.0	—1.2	77.0	104.0
0.5	Na_2SO_4	1.4	35.6	50.8	51.4	101.3	120.9
1.0	$Na_2S_2O_3$	—5.9	24.1	45.3	45.7	38.8	64.8
1.0	KNO_3	11.8‡	31.9	42.6	31.1	81.2	105.7
1.0	$NaNO_3$	11.5	32.3	51.0	40.9	95.7	114.8
0.5	K_2CrO_4	23.9‡	42.8	41.2	40.9	94.6	121.0
0.5	$K_2Cr_2O_7$	72.8	61.1	78.4	68.1	123.6	132.4
0.5	K_2SO_4	1.8	34.7	51.0	40.9	95.7	114.8
0.5	$(NH_4)_2SO_4$	—0.5	37.1	53.2	57.6‡	101.5	125.7
0.25	$K_4FeC_6N_6$	—6.1	33.6	50.7	41.2	— ‡	87.8
0.167	$K_6Fe_2(CN)_{12}$	41.0§	80.8	81.2	130.9	110.7	124.9
1.0	KCNS	—1.2	32.5	52.8	52.7	52.5	72.5
1.0	$NaNO_3$	4.5	35.2	50.2	49.0	103.6	104.6?
0.5	$SrNO_3$	14.8	38.3	50.6	48.7	103.0	119.3
0.125	$Ba(NO_3)_2$	21.9	39.3	51.7	52.8	109.6	121.5
1.0	KNO_3	— ‡	35.6	47.5	49.9	104.8	115.0
0.2	$KClO_3$	15–10‡	39.9	53.8	57.7	105.3	120.9
0.167	$KBrO_3$	13–20‡	40.7	51.3	50.9	111.3	120.8
1.0	NH_4Cl	2.9	32.4	51.3	50.9	81.2	101.7
1.0	KF	2.8	22.5	41.1	50.8	61.3	61.5
1.0	NaCl	—	31.9	51.2	50.3	80.9	101.3
1.0	KBr	2.3	31.7	47.2	52.5	73.6	82.4
1.0	KCl	—	32.1	51.6	52.6	81.6	107.6
0.5	Na_2SO_3	—8.2	28.7	41.0	31.0	68.7	103.7
- ‖	NaOBr	18.4	41.6	73.1	70.6 ‡	89.9	99.7
1.0	$C_4H_6O_6$	5.5	39.7	61.3	54.4§	104.6	123.4
0.5	$C_4H_6O_6$	4.1	41.3	61.6	57.6	110.9	125.7
0.5	$C_4H_4KNaO_6$	—7.9	31.5	51.5	42–47	100.8	119.7

* "Rend. della R. Acc. di Roma," 1890.

† Amalgamated.

‡ Not constant.

§ After some time.

‖ A quantity of bromine was used corresponding to NaOH = 1.

VARIATION OF ELECTRICAL RESISTANCE OF GLASS AND PORCELAIN WITH TEMPERATURE.

The following table gives the values of a, b, and c in the equation

$$\log R = a + bt + ct^2,$$

where R is the specific resistance expressed in ohms, that is, the resistance in ohms per centimetre of a rod one square centimetre in cross section.*

No.	Kind of glass.	Density.	a	b	c	Range of temp. Centigrade.
1	Test-tube glass	-	13.86	—.044	.000065	0°–250°
2	" " "	2.458	14.24	—.055	.0001	37–131
3	Bohemian glass	2.43	16.21	—.043	.0000394	60–174
4	Lime glass (Japanese manufacture) .	2.55	13.14	—.031	—.000021	10–85
5	" " " " .	2.499	14.002	—.025	—.00006	35–95
6	Soda-lime glass (French flask) .	2.533	14.58	—.049	.000075	45–120
7	Potash-soda lime glass . . .	2.58	16.34	—.0425	.0000364	66–193
8	Arsenic enamel flint glass . .	3.07	18.17	—.055	.000088	105–135
9	Flint glass (Thomson's electrometer jar)	3.172	18.021	—.036	—.0000091	100–200
10	Porcelain (white evaporating dish) .	-	15.65	—.042	.00005	68–290

COMPOSITION OF SOME OF THE ABOVE SPECIMENS OF GLASS.

Number of specimen =	3	4	5	7	8	9
Silica	61.3	57.2	70.05	75.65	54.2	55.18
Potash	22.9	21.1	1.44	7.92	10.5	13.28
Soda	Lime, etc.	Lime, etc.	14.32	6.92	7.0	-
Lead oxide	by diff.	by diff.	2.70	-	23.9	31.01
Lime	15.8	16.7	10.33	8.48	0.3	0.35
Magnesia	-	-	-	0.36	0.2	0.06
Arsenic oxide	-	-	-	-	3.5	-
Alumina, iron oxide, etc. .	-	-	1.45	0.70	0.4	0.67

* T. Gray, "Phil. Mag." 1880, and "Proc. Roy. Soc." 1882.

RELATION BETWEEN THERMAL AND ELECTRICAL CONDUCTIVITIES.

That there is a close relation between the thermal and the electrical conductivities of metal was shown experimentally by Wiedemann and Franz in 1853, and had been referred to by Forbes, with whom a difficulty arose with regard to the direction of the variation with temperature. The experiments of Tait and his students have shown that this difficulty was largely, if not entirely, due to experimental error. The same relation has been shown to hold for alloys by Chandler Roberts and by Neumann. This relation was denied by H. F. Weber, and has been again experimentally investigated and apparently established by the experiments of Kirchhoff and Hansemann, of L. Lorenz, of F. Kohlrausch, and of Berget.

Putting l = thermal conductivity, and k = electrical conductivity, Kirchhoff and Hansemann find the values in Table a. This table shows iron to deviate considerably from the other metals in the relationship of the two conductivities; but this may possibly be explained by its magnetic properties.

a. Values in Arbitrary Units at 15° C.

Substance.	l_{15}	k_{15}	$\frac{l_{15}}{k_{15}}$
Lead . .	7.93	4.569	1.74
Tin . . .	14.46	8.823	1.64
Zinc . . .	25.45	14.83	1.72
Copper . .	41.52	24.04	1.73
Iron, No. 1	14.18	6.803	2.08
" " 2	9.64	4.060	2.37
" " 3	13.75	6.565	2.09

Lorenz's results * show that the ratio l/k for the different metals, except iron, is nearly constant for values at 0° and 100° C., but that the ratio is generally greater for poorly conducting substances. He shows that the ratio $\frac{l_{100}}{k_{100}} \div \frac{l_0}{k_0}$ remains nearly constant for all metals examined, with the exception of iron, and has an average value, as shown by Table b, of about 1.37. He concludes that l/k = constant × T, where T is the absolute temperature.

In this table the values of l and k are given in c. g. s. units, and the metals are arranged in the order of their heat conductivities. The same specimens were used for both the thermal and the electrical experiments.

b. Values in C. G. S. Units.

Substances.	l_0	l_{100}	$k_0 \times 10^5$	$k_{100} \times 10^5$	$\frac{l_0}{k_0}$	$\frac{l_{100}}{k_{100}} \div \frac{l_0}{k_0}$
Copper	0.7198	0.7226	45.74	33.82	1574	1.358
Magnesium . . .	0.3760	0.3760	24.47	17.50	1537	1.398
Aluminium . . .	0.3435	0.3619	22.46	17.31	1529	1.367
Brass, red. . . .	0.2460	0.2827	15.75	13.31	1562	1.360
Cadmium	0.2200	0.2045	14.41	10.18	1527	1.315
Brass, yellow . . .	0.2041	0.2540	12.62	11.00	1617	1.428
Iron	0.1665	0.1627	10.37	6.628	1605	1.530
Tin	0.1528	0.1423	9.346	6.524	1635	1.334
Lead.	0.0836	0.0764	5.141	3.602	1627	1.304
German silver . . .	0.0700	0.0887	3.766	3.632	1858	1.314
Antimony	0.0442	0.0396	2.199	1.522	2011	1.294
Bismuth	0.0177	0.0164	0.929	0.633	1900	1.372

c. Berget's Experiments.†

The same specimens were used for both experiments. It will be seen that the ratio is nearly constant, but not exactly so.

Substance.	l	$k \times 10^{-5}$	$\frac{l}{k} 10^{-8}$	Substance.	l	$k \times 10^{-5}$	$\frac{l}{k} 10^{-8}$
Copper. . .	1.0405	65.13	1.6	Tin	0.151	8.33	1.8
Zinc	0.303	18.00	1.7	Lead . . .	0.0810	5.06	1.6
Brass . . .	0.2625	15.47	1.7	Antimony .	0.042	2.47	1.7
Iron	0.1587	9.41	1.7	Mercury . .	0.0201	1.06	1.8

d. Kohlrausch's Results.

An interesting confirmation of the relationship of the two conductivities has been furnished by F. Kohlrausch, who has shown that tempering steel causes equal proportional changes in the thermal and electrical conductivities of the metal, thus leaving the ratio l/k unchanged by the process.‡

Tempered steel	l = 0.062 ; k = 3.3 ; l/k = 0.019
Soft steel	" = 0.111 ; " = 5.5 ; " = 0.020

In the consideration of this subject it must be borne in mind that closely accurate values of thermal conductivity are very difficult to obtain, and hence fairly large variations are to be expected.

* "Wied. Ann." vol. 13, p. 598.
† "Compt. Rend." vol. 110, p. 76.
‡ l is in c. g. s. units and k in terms of mercury.

ELECTROCHEMICAL EQUIVALENTS AND INTERNATIONAL ATOMIC WEIGHTS.

With the exception of the value given for silver and that corresponding to valence 2 for copper, the electrochemical equivalents given in this table have been calculated from the atomic weights and one or two of the more common apparent valences of the substance. The value given for silver is that which was adopted by the International Congress of Electricians at Chicago in 1894. The number for silver is made the basis of the table; the other numbers, with the exception of copper, above referred to, are theoretical.

The International Atomic Weights are quoted from the report of the International Committee on Atomic Weights ("Jour. Am. Chem. Soc.," vol. 25, p. 4).

Substance.	Symbol.	Relative atomic wt. Oxygen = 16.	Relative atomic wt. Hydrogen = 1.	Valence.	Electrochemical equivalent in grammes per coulomb × 1000.
Aluminum	Al	27.1	26.9	3	.0936
Antimony	Sb	120.2	119.3	3	.4150
"	"	"	"	5	.2490
Argon	A	39.9	39.6	—	——
Arsenic	As	75.0	74.4	3	.2590
"	"	"	"	5	.1554
Barium	Ba	137.4	136.4	2	.7116
Bismuth	Bi	208.5	206.9	3	.7199
"	"	"	"	5	.4319
Boron	B	11.	10.9	3	.0380
Bromine	Br	79.96	79.36	1	.8283
Cadmium	Cd	112.4	111.6	2	.5822
Caesium	Cs	133.	132.	1	1.3777
Calcium	Ca	40.1	39.8	2	.2077
Carbon	C	12.0	11.91	4	.0311
Cerium	Ce	140.	139.	2	.7251
Chlorine	Cl	35.45	35.18	1	.3672
Chromium	Cr	52.1	51.7	3	.1800
"	"	"	"	6	.0900
Cobalt	Co	59.0	58.56	2	.3056
"	"	"	"	3	.2038
Columbium	Cb	94.	93.3	5	.1947
Copper	Cu	63.6	63.1	1	.6588
"	"	"	"	2	.3290
Erbium	Er	166.	164.8	2	.8598
Fluorine	F	19.	18.9	1	.1968
Gadolinium	Gd	156.	155.	—	——
Gallium	Ga	70.	69.5	3	.2417
Germanium	Ge	72.5	71.9	—	——
Glucinum	Gl	9.1	9.03	2	.0471
Gold	Au	197.2	195.7	3	.6809
Helium	He	4.	4.	—	——
Hydrogen	H	1.008	1.000	1	.0104
Indium	In	114.	113.1	3	.3936
Iodine	I	126.85	125.90	1	1.3140
Iridium	Ir	193.0	191.5	4	.4998
Iron	Fe	55.9	55.5	2	.2895
"	"	"	"	3	.1930
Krypton	Kr	81.8	81.2	—	——
Lanthanum	La	138.9	137.9	2	.7194
Lead	Pb	206.9	205.35	2	1.0716
Lithium	Li	7.03	6.98	1	.0728
Magnesium	Mg	24.36	24.18	2	.1262
Manganese	Mn	55.0	54.6	2	.2849
"	"	"	"	4	.1424

ELECTROCHEMICAL EQUIVALENTS AND INTERNATIONAL ATOMIC WEIGHTS.

Substance.	Symbol.	Relative atomic wt. Oxygen = 16.	Relative atomic wt. Hydrogen = 1.	Valence.	Electrochemical equivalent in grammes per coulomb × 1000
Mercury . . .	Hg	200.0	198.5	1	2.0717
" . . .	"	"	"	2	1.0359
Molybdenum . .	Mo	96.0	95.3	6	.1657
Neodymium . .	Nd	143.6	142.5	—	——
Neon	Ne	20.	19.9	—	——
Nickel	Ni	58.7	58.3	2	.3040
"	"	"	"	3	.2027
Nitrogen . . .	N	14.04	13.93	3	.0485
" . . .	"	"	"	5	.0291
Osmium . . .	Os	191.	189.6	6	.3297
Oxygen . . .	O	16.00	15.88	2	.0829
Palladium . . .	Pd	106.5	105.7	2	.5516
" . . .	"	"	"	5	.2206
Phosphorous . .	P	31.0	30.77	3	.1070
" . . .	"	"	"	5	.0642
Platinum . . .	Pt	194.8	193.3	2	1.0098
" . . .	"	"	"	4	.5049
Potassium . . .	K	39.15	38.86	1	.4055
Praesodymium . .	Pr	140.5	139.4	—	——
Radium . . .	Rd	225.	223.3	—	——
Rhodium . . .	Rh	103.0	102.2	3	.3556
Rubidium . . .	Rb	85.4	84.8	1	.8846
Ruthenium . . .	Ru	101.7	100.9	4	.2634
Samarium . . .	Sm	150.	148.9	—	——
Scandium . . .	Sc	44.1	43.8	—	——
Selenium . . .	Se	79.2	78.6	2	.4102
Silicon . . .	Si	28.4	28.2	4	.0735
Silver	Ag	107.93	107.12	1	1.1180
Sodium . . .	Na	23.05	22.88	1	.2388
Strontium . . .	Sr	87.6	86.94	2	.4537
Sulphur . . .	S	32.06	31.83	2	.1660
Tantalum . . .	Ta	183.	181.6	5	.3791
Tellurium . . .	Te	127.6	126.6	2	.6609
Terbium . . .	Tb	160.	158.8	—	——
Thallium . . .	Tl	204.1	202.6	1	2.1142
Thorium . . .	Th	232.5	230.8	2	1.2042
Thulium . . .	Tm	171.	169.7	—	——
Tin	Sn	119.0	118.1	2	.6163
"	"	"	"	4	.3082
Titanium . . .	Ti	48.1	47.7	4	.1246
Tungsten . . .	W	184.	182.6	6	.3177
Urnaium . . .	U	238.5	236.7	2	1.2353
" . . .	"	"	"	3	.8235
Vanadium . . .	V	51.2	50.8	3	.1768
" . . .	"	"	"	5	.1061
Xenon	Xe	128.	127.	—	——
Ytterbium . . .	Yb	173.0	171.7	—	——
Yttrium . . .	Yt	89.0	88.3	2	.4610
Zinc	Zn	65.4	64.9	2	.3387
Zirconium . . .	Zr	90.6	89.9	4	.2346

ELECTROCHEMICAL EQUIVALENTS AND INTERNATIONAL ATOMIC WEIGHTS.

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Substance.	Symbol.	Relative atomic wt. Oxygen = 16.	Relative atomic wt. Hydrogen = 1.	Valence.	Electrochemical equivalent in grammes per coulomb × 1000.
Aluminum	Al	27.1	26.9	3	.0936
Antimony	Sb	120.2	119.3	3	.4150
"	"	"	"	5	.2490
Argon	A	39.9	39.6	—	——
Arsenic	As	75.0	74.4	3	.2590
"	"	"	"	5	.1554
Barium	Ba	137.4	136.4	2	.7116
Bismuth	Bi	208.5	206.9	3	.7199
"	"	"	"	5	.4319
Boron	B	11.	10.9	3	.0380
Bromine	Br	79.96	79.36	1	.8283
Cadmium	Cd	112.4	111.6	2	.5822
Caesium	Cs	133.	132.	1	1.3777
Calcium	Ca	40.1	39.8	2	.2077
Carbon	C	12.0	11.91	4	.0311
Cerium	Ce	140.	139.	2	.7251
Chlorine	Cl	35.45	35.18	1	.3672
Chromium	Cr	52.1	51.7	3	.1800
"	"	"	"	6	.0900
Cobalt	Co	59.0	58.56	2	.3056
"	"	"	"	3	.2038
Columbium	Cb	94.	93.3	5	.1947
Copper	Cu	63.6	63.1	1	.6588
"	"	"	"	2	.3290
Erbium	Er	166.	164.8	2	.8598
Fluorine	F	19.	18.9	1	.1968
Gadolinium	Gd	156.	155.	—	——
Gallium	Ga	70.	69.5	3	.2417
Germanium	Ge	72.5	71.9	—	——
Glucinum	Gl	9.1	9.03	2	.0471
Gold	Au	197.2	195.7	3	.6809
Helium	He	4.	4.	—	——
Hydrogen	H	1.008	1.000	1	.0104
Indium	In	114.	113.1	3	.3936
Iodine	I	126.85	125.90	1	1.3140
Iridium	Ir	193.0	191.5	4	.4998
Iron	Fe	55.9	55.5	2	.2895
"	"	"	"	3	.1930
Krypton	Kr	81.8	81.2	—	——
Lanthanum	La	138.9	137.9	2	.7194
Lead	Pb	206.9	205.35	2	1.0716
Lithium	Li	7.03	6.98	1	.0728
Magnesium	Mg	24.36	24.18	2	.1262
Manganese	Mn	55.0	54.6	2	.2849
"	"	"	"	4	.1424

ELECTROCHEMICAL EQUIVALENTS AND INTERNATIONAL ATOMIC WEIGHTS.

Substance.	Symbol.	Relative atomic wt. Oxygen = 16.	Relative atomic wt. Hydrogen = 1.	Valence.	Electrochemical equivalent in grammes per coulomb × 1000
Mercury	Hg	200.0	198.5	1	2.0717
"	"	"	"	2	1.0359
Molybdenum	Mo	96.0	95.3	6	.1657
Neodymium	Nd	143.6	142.5	—	——
Neon	Ne	20.	19.9	—	——
Nickel	Ni	58.7	58.3	2	.3040
"	"	"	"	3	.2027
Nitrogen	N	14.04	13.93	3	.0485
"	"	"	"	5	.0291
Osmium	Os	191.	189.6	6	.3297
Oxygen	O	16.00	15.88	2	.0829
Palladium	Pd	106.5	105.7	2	.5516
"	"	"	"	5	.2206
Phosphorous	P	31.0	30.77	3	.1070
"	"	"	"	5	.0642
Platinum	Pt	194.8	193.3	2	1.0098
"	"	"	"	4	.5049
Potassium	K	39.15	38.86	1	.4055
Praesodymium	Pr	140.5	139.4	—	——
Radium	Rd	225.	223.3	—	——
Rhodium	Rh	103.0	102.2	3	.3556
Rubidium	Rb	85.4	84.8	1	.8846
Ruthenium	Ru	101.7	100.9	4	.2634
Samarium	Sm	150.	148.9	—	——
Scandium	Sc	44.1	43.8	—	——
Selenium	Se	79.2	78.6	2	.4102
Silicon	Si	28.4	28.2	4	.0735
Silver	Ag	107.93	107.12	1	1.1180
Sodium	Na	23.05	22.88	1	.2388
Strontium	Sr	87.6	86.94	2	.4537
Sulphur	S	32.06	31.83	2	.1660
Tantalum	Ta	183.	181.6	5	.3791
Tellurium	Te	127.6	126.6	2	.6609
Terbium	Tb	160.	158.8	—	——
Thallium	Tl	204.1	202.6	1	2.1142
Thorium	Th	232.5	230.8	2	1.2042
Thulium	Tm	171.	169.7	—	——
Tin	Sn	119.0	118.1	2	.6163
"	"	"	"	4	.3082
Titanium	Ti	48.1	47.7	4	.1246
Tungsten	W	184.	182.6	6	.3177
Urnaium	U	238.5	236.7	2	1.2353
"	"	"	"	3	.8235
Vanadium	V	51.2	50.8	3	.1768
"	"	"	"	5	.1061
Xenon	Xe	128.	127.	—	——
Ytterbium	Yb	173.0	171.7	—	——
Yttrium	Yt	89.0	88.3	2	.4610
Zinc	Zn	65.4	64.9	2	.3387
Zirconium	Zr	90.6	89.9	4	.2346

PERMEABILITY OF IRON.

TABLE 284. — Permeability of Iron Rings and Wire.

This table gives, for a few specimens of iron, the magnetic induction B, and permeability μ, corresponding to the magneto-motive forces H recorded in the first column. The first specimen is taken from a paper by Rowland,* and refers to a welded and annealed ring of "Burden's Best" wrought iron. The ring was 6.77 cms. in mean diameter, and the bar had a cross sectional area of 0.916 sq. cms. Specimens 2–4 are taken from a paper by Bosanquet,† and also refers to soft iron rings. The mean diameters were 21.5, 22.1, and 22.725 cms., and the thickness of the bars 2.535, 1.295, and .7544 cms. respectively. These experiments were intended to illustrate the effect of thickness of bar on the induction. Specimen 5 is from Ewing's book,‡ and refers to one of his own experiments on a soft iron wire .077 cms. diameter and 30.5 cms. long.

H	Specimen 1		2		3		4		5	
	B	μ	B	μ	B	μ	B	μ	B	μ
0.2	80	400	126	630	65	325	85	425	22	110
0.5	330	660	377	754	224	448	214	428	74	148
1.0	1450	1450	1449	1449	840	840	885	885	246	246
2.0	4840	2420	4564	2282	3533	1766	2417	1208	950	475
5.0	9880	1976	9900	1980	8293	1659	8884	1777	12430	2486
10.0	12970	1297	13023	1302	12540	1254	11388	1139	15020	1502
20.0	14740	737	14911	746	14710	735	13273	664	15790	789
50.0	16390	328	16217	324	16062	321	13890	278	–	–
100.0	–	–	17148	171	17900	179	14837	148	–	–

NOTE. — The comparatively high value of the magnetizing force required for maximum permeability when the specimen is a thin drawn wire is noticeable in specimen 5.

TABLE 285. — Permeability of Transformer Iron.§

This table contains the results of some experiments on transformers of the Westinghouse and Thomson-Houston types. Referring to the headings of the different columns, M is the total magneto-motive force applied to the iron; M/l the magneto-motive force per centimetre length of the iron circuit: B the total induction through the magnetizing coil; B/a the induction per square centimetre of the mean section of the iron core; M/B the magnetic reluctance of the iron circuit; Bl/Ma the permeability of the iron, a being taken as the mean cross section of the iron circuit as it exists in the transformer, which is thus slightly greater than the actual cross section of the iron.

(a) WESTINGHOUSE NO. 8 TRANSFORMERS (ABOUT 2500 WATTS CAPACITY).

M	$\frac{M}{l}$	First specimen.				Second specimen.			
		B	$\frac{B}{a}$	$\frac{M}{B}$	$\frac{Bl}{Ma}$	B	$\frac{B}{a}$	$\frac{M}{B}$	$\frac{Bl}{Ma}$
20	0.597	218×10^3	1406	0.917×10^{-4}	2360	16×10^4	1032	1.25×10^{-4}	1730
40	1.194	587 "	3790	0.681 "	3120	49 "	3140	0.82 "	2640
60	1.791	878 "	5660	0.683 "	3180	82 "	5290	0.73 "	2970
80	2.338	1091 "	7040	0.734 "	2960	104 "	6710	0.77 "	2820
100	2.985	1219 "	7860	0.819 "	2640	118 "	7610	0.85 "	2560
120	3.582	1330 "	8580	0.903 "	2410	124 "	8000	0.97 "	2250
140	4.179	1405 "	9060	0.994 "	2186	131 "	8450	1.07 "	2036
160	4.776	1475 "	9510	1.090 "	2000	135 "	8710	1.18 "	1830
180	5.373	1532 "	9880	1.180 "	1850	140 "	9030	1.29 "	1690
200	5.970	1581 "	10200	1.270 "	1720	142 "	9160	1.41 "	1540
220	6.567	1618 "	10430	1.360 "	1590	144 "	9290	1.53 "	1410
260	7.761	1692 "	10910	1.540 "	1410	–	–	–	–

* "Phil. Mag." 4th series, vol. xlv. p. 151.
† Ibid. 5th series, vol. xix. p. 73.
‡ "Magnetic Induction in Iron and Other Metals."
§ T. Gray, from special experiments.

PERMEABILITY OF TRANSFORMER IRON.

(b) WESTINGHOUSE NO. 6 TRANSFORMERS (ABOUT 1800 WATTS CAPACITY).

		First specimen.				Second specimen.			
M	$\frac{M}{l}$	B	$\frac{B}{a}$	$\frac{M}{B}$	$\frac{Bl}{Ma}$	B	$\frac{B}{a}$	$\frac{M}{B}$	$\frac{Bl}{Ma}$
20	0.62	147×10^3	1320	1.36×10^{-4}	2140	215×10^3	1940	0.93×10^{-4}	3140
40	1.23	442 "	3980	0.91 "	3260	615 "	5540	0.64 "	4490
60	1.85	697 "	6280	0.86 "	3390	826 "	7440	0.72 "	4030
80	2.46	862 "	7770	0.93 "	3140	986 "	8880	0.81 "	3590
100	3.08	949 "	8550	1.05 "	2770	1050 "	9460	0.95 "	3060
120	3.70	1010 "	9106	1.19 "	2450	1100 "	9910	1.09 "	2670
140	4.31	1060 "	9550	1.33 "	2210	1140 "	10300	1.23 "	2430
160	4.93	1090 "	9820	1.47 "	1990	1170 "	10500	1.37 "	2180
180	5.55	1120 "	10100	1.61 "	1830	1190 "	10700	1.51 "	1970
200	6.16	1150 "	10400	1.74 "	1680	–	–	–	–

(c) WESTINGHOUSE NO. 4 TRANSFORMER (ABOUT 1200 WATTS CAPACITY).

M	$\frac{M}{l}$	B	$\frac{B}{a}$	$\frac{M}{B}$	$\frac{Bl}{Ma}$
20	0.69	147×10^3	1470	1.36×10^{-4}	2140
40	1.38	406 "	4066	0.98 "	2940
60	2.07	573 "	5730	1.05 "	2770
80	2.76	659 "	6590	1.21 "	2390
100	3.45	714 "	7140	1.40 "	2070
120	4.14	748 "	7490	1.60 "	1810
140	4.83	777 "	7770	1.80 "	1610

(d) THOMSON-HOUSTON 1500 WATTS TRANSFORMER.

M	$\frac{M}{l}$	B	$\frac{B}{a}$	$\frac{M}{B}$	$\frac{Bl}{Ma}$
20	0.42	70×10^3	1560	2.86×10^{-4}	3730
40	0.84	142 "	3160	2.81 "	3780
60	1.26	214 "	4770	2.81 "	3790
80	1.68	265 "	5910	3.02 "	3520
100	2.10	309 "	6890	3.24 "	3280
120	2.52	348 "	7760	3.45 "	3080
160	3.36	408 "	9100	3.92 "	2710
200	4.20	456 "	10200	4.39 "	2430
240	5.04	495 "	11000	4.87 "	2190
280	5.88	524 "	11690	5.35 "	1990
320	6.72	550 "	12270	5.82 "	1820
360	7.56	573 "	12780	6.29 "	1690
400	8.40	591 "	13180	6.78 "	1570
440	9.24	504 "	13470	7.28 "	1460

Table 288.

COMPOSITION AND MAGNETIC

This table and Table 289 below are taken from a paper by Dr. Hopkinson * on the magnetic properties of iron and steel.
which is stated in the paper to have been 240. The maximum magnetization is not tabulated; but as stated in the
by 4π. "Coercive force" is the magnetizing force required to reduce the magnetization to zero. The "demag-
previous magnetization in the opposite direction to the "maximum induction" stated in the table. The "energy
which, however, was only found to agree roughly with the results of experiment.

No. of Test.	Description of specimen.	Temper.	Chemical analysis.					
			Total Carbon.	Manganese.	Sulphur.	Silicon.	Phosphorus.	Other substances.
1	Wrought iron . . .	Annealed	–	–	–	–	–	–
2	Malleable cast iron . .	"	–	–	–	–	–	–
3	Gray cast iron . . .	–	–	–	–	–	–	–
4	Bessemer steel . . .	–	0.045	0.200	0.030	None.	0.040	–
5	Whitworth mild steel .	Annealed	0.090	0.153	0.016	"	0.042	–
6	" " .	"	0.320	0.438	0.017	0.042	0.035	–
7	" " .	Oil-hardened	"	"	"	"	"	–
8	" " .	Annealed	0.890	0.165	0.005	0.081	0.019	–
9	" " .	Oil-hardened	"	"	"	"	"	–
10	Hadfield's manganese steel .	–	1.005	12.360	0.038	0.204	0.070	–
11	Manganese steel . .	As forged	0.674	4.730	0.023	0.608	0.078	–
12	" " . .	Annealed	"	"	"	"	"	–
13	" " . .	Oil-hardened	"	"	"	"	"	–
14	" " . .	As forged	1.298	8.740	0.024	0.094	0.072	–
15	" " . .	Annealed	"	"	"	"	"	–
16	" " . .	Oil-hardened	"	"	"	"	"	–
17	Silicon steel . . .	As forged	0.685	0.694	"	3.438	0.123	–
18	" " . . .	Annealed	"	"	"	"	"	–
19	" " . . .	Oil-hardened	"	"	"	"	"	–
20	Chrome steel . . .	As forged	0.532	0.393	0.020	0.220	0.041	0.621 Cr.
21	" " . . .	Annealed	"	"	"	"	"	"
22	" " . . .	Oil-hardened	"	"	"	"	"	"
23	" " . . .	As forged	0.687	0.028	"	0.134	0.043	1.195 Cr.
24	" " . . .	Annealed	"	"	"	"	"	"
25	" " . . .	Oil-hardened	"	"	"	"	"	"
26	Tungsten steel . . .	As forged	1.357	0.036	None.	0.043	0.047	4.649 W.
27	" " . . .	Annealed	"	"	"	"	"	"
28	" " . . .	Hardened in cold water	"	"	"	"	"	"
29	" " . . .	Hardened in tepid water	"	"	"	"	"	"
30	" " (French) .	Oil-hardened	0.511	0.625	None.	0.021	0.028	3.444 W.
31	" " . . .	Very hard	0.855	0.312	–	0.151	0.089	2.353 W.
32	Gray cast iron . . .	–	3.455	0.173	0.042	2.044	0.151	2.064 C.†
33	Mottled cast iron . .	–	2.581	0.610	0.105	1.476	0.435	1.477 C.†
34	White " " . .	–	2.036	0.386	0.467	0.764	0.458	–
35	Spiegeleisen . .	–	4.510	7.970	Trace.	0.502	0.128	–

* Phil. Trans. Roy. Soc. vol. 176.

† Graphitic carbon.

PROPERTIES OF IRON AND STEEL.

The numbers in the columns headed "magnetic properties" give the results for the highest magnetizing force used, paper, it may be obtained by subtracting the magnetizing force (240) from the maximum induction and then dividing netizing force" is the magnetizing force which had to be applied in order to leave no residual magnetization after dissipated" was calculated from the formula:— Energy dissipated = coercive force × maximum induction ÷ π

No. of Test.	Description of specimen.	Temper.	Specific electrical resistance.	Magnetic properties. Maximum induction.	Residual induction.	Coercive force.	Demagnetizive force.	Energy dissipated per cycle.
1	Wrought iron . . .	Annealed	.01378	18251	7248	2.30	–	13356
2	Malleable cast iron . .	"	.03254	12408	7479	8.80	–	34742
3	Gray cast iron . . .	–	.10560	10783	3928	3.80	–	13037
4	Bessemer steel . . .	–	.01050	18196	7860	2.96	–	17137
5	Whitworth mild steel .	Annealed	.01080	19840	7080	1.63	–	10289
6	" " .	"	.01446	18736	9840	6.73	–	40120
7	" " .	Oil-hardened	.01390	18796	11040	11.00	–	65786
8	" " .	Annealed	.01559	16120	10740	8.26	–	42366
9	" " .	Oil-hardened	.01695	16120	8736	19.38	–	99401
10	Hadfield's manganese steel .	–	.06554	310	–	–		–
11	Manganese steel . .	As forged	.05368	4623	2202	23.50	37.13	34567
12	" " . .	Annealed	.03928	10578	5848	33.86	46.10	113963
13	" " . .	Oil-hardened	.05556	4769	2158	27.64	40.29	41941
14	" " . .	As forged	.06993	747	–	–	–	–
15	" " . .	Annealed	.06316	1985	540	24.50	50.39	15474
16	" " . .	Oil-hardened	.07066	733	–	–	–	–
17	Silicon steel . . .	As forged	.06163	15148	11073	9.49	12.60	45740
18	" " . . .	Annealed	.06185	14701	8149	7.80	10.74	36485
19	" " . . .	Oil-hardened	.06195	14696	8084	12.75	17.14	59619
20	Chrome steel . . .	As forged	.02016	15778	9318	12.24	13.87	61439
21	" " . . .	Annealed	.01942	14848	7570	8.98	12.24	42425
22	" " . . .	Oil-hardened	.02708	13960	8595	38.15	48.45	169455
23	" " . . .	As forged	.01791	14680	7568	18.40	22.03	85944
24	" " . . .	Annealed	.01849	13233	6489	15.40	19.79	64842
25	" " . . .	Oil-hardened	.03035	12868	7891	40.80	56.70	167050
26	Tungsten steel . . .	As forged	.02249	15718	10144	15.71	17.75	78568
27	" " . . .	Annealed	.02250	16498	11008	15.30	16.93	80315
28	" " . . .	Hardened in cold water	.02274	–	–	–	–	–
29	" " . . .	Hardened in tepid water	.02249	15610	9482	30.10	34.70	149500
30	" " (French) .	Oil hardened	.03604	14480	8643	47.07	64.46	216864
31	" " . . .	Very hard	.04427	12133	6818	51.20	70.69	197660
32	Gray cast iron . . .	–	.11400	9148	3161	13.67	17.03	39789
33	Mottled cast iron . .	–	.06286	10546	5108	12.24	–	41072
34	White " " . .	–	.05661	9342	5554	12.24	20.40	36383
35	Spiegeleisen . . .	–	.10520	385	77	–	–	–

Table 287.

PERMEABILITY OF SOME OF THE SPECIMENS IN TABLE 286.

This table gives the induction and the permeability for different values of the magnetizing force of some of the specimens in Table 286. The specimen numbers refer to the same table. The numbers in this table have been taken from the curves given by Dr. Hopkinson, and may therefore be slightly in error; they are the mean values for rising and falling magnetizations.

Magnetizing force. H	Specimen 1 (iron).		Specimen 8 (annealed steel).		Specimen 9 (same as 8 tempered).		Specimen 3 (cast iron).	
	B	μ	B	μ	B	μ	B	μ
1	-	-	-	-	-	-	265	265
2	200	100	-	-	-	-	700	350
3	-	-	-	-	-	-	1625	542
5	10050	2010	1525	300	750	150	3000	600
10	12550	1255	9000	900	1650	165	5000	500
20	14550	727	11500	575	5875	294	6000	300
30	15200	507	12650	422	9875	329	6500	217
40	15800	395	13300	332	11600	290	7100	177
50	16000	320	13800	276	12000	240	7350	149
70	16360	234	14350	205	13400	191	7900	113
100	16800	168	14900	149	14500	145	8500	85
150	17400	116	15700	105	15800	105	9500	63
200	17950	90	16100	80	16100	80	10190	51

Tables 288–292 give the results of some experiments by Du Bois,* on the magnetic properties of iron, nickel, and cobalt under strong magnetizing forces. The experiments were made on ovoids of the metals 18 centimetres long and 0.6 centimetres diameter. The specimens were as follows: (1) Soft Swedish iron carefully annealed and having a density 7.82. (2) Hard English cast steel yellow tempered at 230° C.; density 7.78. (3) Hard drawn best nickel containing 99 % Ni with some SiO_2 and traces of Fe and Cu; density 8.82. (4) Cast cobalt giving the following composition on analysis: Co = 93.1, Ni = 5.8, Fe = 0.8, Cu = 0.2, Si = 0.1, and C = 0.3. The specimen was very brittle and broke in the lathe, and hence contained a surfaced joint held together by clamps during the experiment. Referring to the columns, H, B, and μ have the same meaning as in the other tables, S is the magnetic moment per gramme, and I the magnetic moment per cubic centimetre. H and S are taken from the curves published by Du Bois; the others have been calculated using the densities given.

Table 288.

MAGNETIC PROPERTIES OF SOFT IRON AT 0° AND 100° C.

Soft iron at 0° C.					Soft iron at 100° C.				
H	S	I	B	μ	H	S	I	B	μ
100	180.0	1408	17790	177.9	100	180.0	1402	17720	177.2
200	194.5	1521	19310	96.5	200	194.0	1511	19190	96.0
400	208.0	1627	20830	52.1	400	207.0	1613	20660	51.6
700	215.5	1685	21870	31.2	700	213.4	1663	21590	29.8
1000	218.0	1705	22420	22.4	1000	215.0	1674	22040	21.0
1200	218.5	1709	22670	18.9	1200	215.5	1679	22300	18.6

Tables 289.

MAGNETIC PROPERTIES OF STEEL AT 0° AND 100° C.

Steel at 0° C.					Steel at 100° C.				
H	S	I	B	μ	H	S	I	B	μ
100	165.0	1283	16240	162.4	100	165.0	1278	16170	161.7
200	181.0	1408	17900	89.5	200	180.0	1395	17730	88.6
400	193.0	1500	19250	48.1	400	191.0	1480	19000	47.5
700	199.5	1552	20210	28.9	700	197.0	1527	19890	28.4
1000	203.5	1583	20900	20.9	1000	199.0	1543	20380	20.4
1200	205.0	1595	21240	17.7	1500	203.0	1573	21270	14.2
3750†	212.0	1650	24470	6.5	3000	205.5	1593	23020	7.7
					5000	208.0	1612	25260	5.1

* "Phil. Mag." 5 series, vol. xxix.

† The results in this and the other tables for forces above 1200 were not obtained from the ovoids above referred to, but from a small piece of the metal provided with a polished mirror surface and placed, with its polished face normal to the lines of force. between the poles of a powerful electromagnet. The induction was then inferred from the rotation of the plane of a polarized ray of red light reflected normally from the surface. (See Kerr's "Constants," p. 292.)

MAGNETIC PROPERTIES OF METALS.

TABLE 290. — Cobalt at 100° C.

H	S	I	B	μ
200	106	848	10850	54.2
300	116	928	11960	39.9
500	127	1016	13260	26.5
700	131	1048	13870	19.8
1000	134	1076	14520	14.5
1500	138	1104	15380	10.3
2500	143	1144	16870	6.7
4000	145	1164	18630	4.7
6000	147	1176	20780	3.5
9000	149	1192	23980	2.6
At 0° C. this specimen gave the following results:				
7900	154	1232	23380	3.0

TABLE 291. — Nickel at 100° C.

H	S	I	B	μ
100	35.0	309	3980	39.8
200	43.0	380	4966	24.8
300	46.0	406	5399	18.0
500	50.0	441	6043	12.1
700	51.5	454	6409	9.1
1000	53.0	468	6875	6.9
1500	56.0	494	7707	5.1
2500	58.4	515	8973	3.6
4000	59.0	520	10540	2.6
6000	59.2	522	12561	2.1
9000	59.4	524	15585	1.7
12000	59.6	526	18606	1.5
At 0° C. this specimen gave the following results:				
12300	67.5	595	19782	1.6

TABLE 292. — Magnetite.

The following results are given by Du Bois * for a specimen of magnetite.

H	I	B	μ
500	325	8361	16.7
1000	345	9041	9.0
2000	350	10084	5.0
12000	350	20084	1.7

Professor Ewing has investigated the effects of very intense fields on the induction in iron and other metals.† The results show that the intensity of magnetization does not increase much in iron after the field has reached an intensity of 1000 c. g. s. units, the increase of induction above this being almost the same as if the iron were not there, that is to say, dB/dH is practically unity. For hard steels, and particularly manganese steels, much higher forces are required to produce saturation. Hadfield's manganese steel seems to have nearly constant susceptibility up to a magnetizing force of 10,000. The following tables, taken from Ewing's papers, illustrate the effects of strong fields on iron and steel. The results for nickel and cobalt do not differ greatly from those given above.

TABLE 293. — Lowmoor Wrought Iron.

H	I	B	μ
3080	1680	24130	7.83
6450	1740	28300	4.39
10450	1730	32250	3.09
13600	1720	35200	2.59
16390	1630	36810	2.25
18760	1680	39900	2.13
18980	1730	40730	2.15

TABLE 294. — Vicker's Tool Steel.

H	I	B	μ
6210	1530	25480	4.10
9970	1570	29650	2.97
12120	1550	31620	2.60
14660	1580	34550	2.36
15530	1610	35820	2.31

TABLE 295. — Hadfield's Manganese Steel.

H	I	B	μ
1930	55	2620	1.36
2380	84	3430	1.44
3350	84	4400	1.31
5920	111	7310	1.24
6620	187	8970	1.35
7890	191	10290	1.30
8390	263	11690	1.39
9810	396	14790	1.51

TABLE 296. — Saturation Values for Steels of Different Kinds.

		H	I	B	μ
1	Bessemer steel containing about 0.4 per cent carbon . . .	17600	1770	39880	2.27
2	Siemens-Marten steel containing about 0.5 per cent carbon	18000	1660	38860	2.16
3	Crucible steel for making chisels, containing about 0.6 per cent carbon	19470	1480	38010	1.95
4	Finer quality of 3 containing about 0.8 per cent carbon . .	18330	1580	38190	2.08
5	Crucible steel containing 1 per cent carbon	19620	1440	37690	1.92
6	Whitworth's fluid-compressed steel	18700	1590	38710	2.07

* "Phil. Mag." 5 series, vol. xxix.

† "Phil. Trans. Roy. Soc." 1885 and 1889.

TABLE 297.

MAGNETIC PROPERTIES OF IRON IN VERY WEAK FIELDS.

The effect of very small magnetizing forces has been studied by C. Baur * and by Lord Rayleigh.† The following short table is taken from Baur's paper, and is taken by him to indicate that the susceptibility is finite for zero values of H and for a finite range increases in simple proportion to H. He gives the formula $k = 15 + 100\,H$, or $I = 15\,H + 100\,H^2$. The experiments were made on an annealed ring of round bar 1.013 cms. radius, the ring having a radius of 9.432 cms. Lord Rayleigh's results for an iron wire not annealed give $k = 6.4 + 5.1\,H$, or $I = 6.4\,H + 5.1\,H^2$. The forces were reduced as low as 0.00004 c. g. s., the relation of k to H remaining constant.

First experiment.			Second experiment.	
H	k	I	H	k
.01580	16.46	2.63	.0130	15.50
.03081	17.65	5.47	.0847	18.38
.07083	23.00	16.33	.0946	20.49
.13188	28.90	38.15	.1864	25.07
.23011	39.81	91.56	.2903	32.40
.38422	58.56	224.87	.3397	35.20

TABLES 298, 299.

DISSIPATION OF ENERGY IN CYCLIC MAGNETIZATION OF MAGNETIC SUBSTANCES.

When a piece of iron or other magnetic metal is made to pass through a closed cycle of magnetization dissipation of energy results. Let us suppose the iron to pass from zero magnetization to strong magnetization in one direction and then gradually back through zero to strong magnetization in the other direction and thence back to zero, and this operation to be repeated several times. The iron will be found to assume the same magnetization when the same magnetizing force is reached from the same direction of change, but not when it is reached from the other direction. This has been long known, and is particularly well illustrated in the permanency of hard steel magnets. That this fact involves a dissipation of energy which can be calculated from the open loop formed by the curves giving the relation of magnetization to magnetizing force was pointed out by Warburg ‡ in 1881, reference being made to experiments of Thomson, § where such curves are illustrated for magnetism, and to E. Cohn, ‖ where similar curves are given for thermoelectricity. The results of a number of experiments and calculations of the energy dissipated are given by Warburg. The subject was investigated about the same time by Ewing, who published results somewhat later. ¶ Extensive investigations have since been made by a number of investigators.

TABLE 298.—Soft Iron Wire.

(From Ewing's 1885 paper.)

Total induction per sq. cm. B	Dissipation of energy in ergs per cu. cm.	Horse-power wasted per ton at 100 cycles per sec.
2000	420	0.74
3000	800	1.41
4000	1230	2.18
5000	1700	3.01
6000	2200	3.89
7000	2760	4.88
8000	3450	6.10
9000	4200	7.43
10000	5000	8.84
11000	5820	10.30
12000	6720	11.89
13000	7650	13.53
14000	8650	15.30
15000	9670	17.10

TABLE 299.—Cable Transformers.

This table gives the results obtained by Alexander Siemens with one of Siemens' cable transformers. The transformer core consisted of 900 soft iron wires 1 mm. diameter and 6 metres long.** The dissipation of energy in watts is for 100 complete cycles per second.

Mean maximum induction density in core. B	Total observed dissipation of energy in the core in watts per 112 lbs.	Calculated eddy current loss in watts per 112 lbs.	Hysteresis loss of energy in watts per 112 lbs.	Hysteresis loss of energy in ergs per cu. cm. per cycle.
1000	43.2	4	39.2	602
2000	96.2	16	80.2	1231
3000	158.0	36	122.0	1874
4000	231.2	64	167.2	2566
5000	309.5	100	209.5	3217
6000	390.1	144	246.1	3779

* "Wied. Ann." vol. xi.
† "Phil. Mag." vol. xxiii.
‡ "Wied. Ann." vol. xiii. p. 141.
§ "Phil. Trans. Roy. Soc." vol. 175.
‖ "Wied. Ann." vol. 6.
¶ "Proc. Roy. Soc." 1882, and "Trans. Roy. Soc." 1885.
** "Proc. Inst. of Elect. Eng." Lond., 1892.

DISSIPATION OF ENERGY IN THE CYCLIC MAGNETIZATION OF VARIOUS SUBSTANCES.

C. P. Steinmetz concludes from his experiments* that the dissipation of energy due to hysteresis in magnetic metals can be expressed by the formula $e = aB^{1.6}$, where e is the energy dissipated and a a constant. He also concludes that the dissipation is the same for the same range of induction, no matter what the absolute value of the terminal inductions may be. His experiments show this to be nearly true when the induction does not exceed $\pm$ 15000 c. g. s. units per sq. cm. It is possible that, if metallic induction only be taken, this may be true up to saturation ; but it is not likely to be found to hold for total inductions much above the saturation value of the metal. The law of variation of dissipation with induction range in the cycle, stated in the above formula, is also subject to verification.†

Values of Constant a.

The following table gives the values of the constant a as found by Steinmetz for a number of different specimens. The data are taken from his second paper.

Number of specimen.	Kind of material.	Description of specimen.	Value of a.
1	Iron	Norway iron	.00227
2	"	Wrought bar	.00326
3	"	Commercial ferrotype plate	.00548
4	"	Annealed " "	.00458
5	"	Thin tin plate	.00286
6	"	Medium thickness tin plate	.00425
7	Steel	Soft galvanized wire	.00349
8	"	Annealed cast steel	.00848
9	"	Soft annealed cast steel	.00457
10	"	Very soft annealed cast steel	.00318
11	"	Same as 8 tempered in cold water	.02792
12	"	Tool steel glass hard tempered in water	.07476
13	"	" " tempered in oil	.02670
14	"	" " annealed	.01899
15	"	Same as 12, 13, and 14, after having been subjected to an alternating m. m. f. of from 4000 to 6000 ampere turns for demagnetization	.06130
16	"		.02700
17	"		.01445
18	Cast iron	Gray cast iron	.01300
19	" "	" " " containing $\frac{1}{8}$ % aluminium	.01365
20	" "	" " " " $\frac{1}{2}$ % "	.01459
21	Magnetite	A square rod 6 sq. cms. section and 6.5 cms. long, from the Tilly Foster mines, Brewsters, Putnam County, New York, stated to be a very pure sample	.02348
22	Nickel	Soft wire	.0122
23	"	Annealed wire, calculated by Steinmetz from Ewing's experiments	.0156
24	"	Hardened, also from Ewing's experiments	.0385
25	Cobalt	Rod containing about 2 % of iron, also calculated from Ewing's experiments by Steinmetz	.0120
26	Iron filings	Consisted of thin needle-like chips obtained by milling grooves about 8 mm. wide across a pile of thin sheets clamped together. About 30 % by volume of the specimen was iron.	
		1st experiment, continuous cyclic variation of m. m. f. 180 cycles per second	.0457
		2d experiment, 114 cycles per second	.0396
		3d " 79–91 cycles per second	.0373

* "Trans. Am. Inst. Elect. Eng." January and September, 1892.
† See T. Gray, "Proc. Roy. Soc." vol. lvi.

DISSIPATION OF ENERGY IN THE CYCLIC MAGNETIZATION OF TRANSFORMER CORES.*

This table gives, for the most part, results obtained for transformer cores. The electromagnet core formed a closed iron circuit of about 320 sq. cms. section and was made up of sheets of Bessemer steel about 1-20 inch thick. The No. 20 transformer had a core of soft steel sheets about 7-1000 inch thick insulated from each other by sheets of thin paper. The cores of the other transformers were formed of soft steel sheets 15-1000 inch thick insulated from each other by their oxidized surfaces only. The following are the particulars of the data given in the different columns: —

Column 1. Description of specimen.
" 2. The total energy, in joules per cycle, required to produce the magnetic induction given in column *B*
" 3. The energy, in joules per cycle, returned to the circuit on reversal of the magnetizing force.
" 4. The energy dissipated, in joules per cycle, or the difference of columns 2 and 3.
" 5, 6, and 7. The quantities in columns 2, 3, and 4 reduced to ergs per cubic centimetre of the core.
" *B*. The maximum induction in c. g. s. units per sq. cm.

1	2	3	4	5	6	7	B
Electromagnet	6.5	0.9	5.6	1010	140	867	2660
	24.4	2.6	21.8	3800	406	3400	6700
	66.8	10.4	56.4	10400	1620	8800	11600
	81.4	15.4	66.0	12700	2400	10300	12700
	96.6	21.8	74.8	15100	3400	11700	14100
	126.2	38.2	88.0	19700	5960	13700	15200
	153.0	57.6	95.4	23900	8990	14900	15900
	178.4	79.2	99.2	27800	12400	15500	16600
	221.2	116.8	104.4	34500	18300	16300	17240
	275.6	168.0	107.6	42900	26200	16800	17420
Westinghouse No 20 transformer	1.31	0.30	1.01	1435	328	1107	2330
	4.65	1.10	3.55	5110	1210	3900	4980
	8.25	1.62	6.63	9060	1780	7280	6620
	10.36	1.89	8.47	11350	2070	9280	7720
	12.20	2.98	9.22	13440	3280	10160	8250
	18.20	5.15	13.05	19980	5660	14320	9690
Westinghouse No. 8 transformer, specimen 1	0.45	0.055	0.400	875	105	770	3480
	0.80	0.102	0.101	1544	196	1348	5140
	1.66	0.199	1.460	3200	380	2820	7570
	2.42	0.406	2.010	4650	780	3870	9250
	3.54	0.795	2.750	6820	1530	5290	10940
Westinghouse No. 8 transformer, specimen 2	0.399	0.046	0.353	768	88	680	3060
	0.820	0.085	0.735	1574	164	1410	4830
	1.713	0.183	1.530	3300	352	2948	7570
	2.663	0.343	2.320	5120	660	4460	9270
Westinghouse No. 6 transformer, specimen 1	0.488	0.062	0.426	1360	172	1188	4640
	0.814	0.096	0.718	2260	266	1994	6760
	1.430	0.205	1.225	3980	570	3410	9370
	2.000	0.330	1.670	5560	918	4642	10950
Westinghouse No. 6 transformer, specimen 2	0.722	0.100	0.622	2000	278	1722	7290
	1.048	0.164	0.884	2920	456	2464	9000
	1.379	0.222	1.157	3830	616	3214	9990
	1.731	0.328	1.403	4810	912	3898	11210
Westinghouse No. 4 transformer	0.355	0.044	0.311	1210	152	1058	4540
	0.549	0.074	0.475	1880	255	1625	5920
	0.783	0.126	0.657	2690	433	2257	7[illegible]40
	0 970	0.175	0.795	3340	603	2737	7800
Thomson-Houston 1500 watt transformer	0.413	0.105	0.308	1930	490	1440	6150
	0.681	0.189	0.492	3190	880	2310	8250
	1.207	0.389	0.818	5660	1830	3830	11110
	1.797	0.710	1.087	8420	3320	5100	13290

* T. Gray, from special experiments; see Table 285 for other properties.

DISSIPATION OF ENERGY DUE TO MAGNETIC HYSTERESIS IN IRON.*

The first column gives the maximum magnetic induction *B* per square centimetre in c. g. s. units. The other columns give the dissipation of energy in ergs per cycle per cubic centimetre for the iron specified in the foot-note.

B	1	2	3	4	5	6	7
2000	400	420	530	600	750	930	1100
3000	780	800	1050	1150	1350	1700	2150
4000	1200	1260	1670	1780	2030	2600	3300
5000	1680	1770	2440	2640	2810	3800	4700
6000	2200	2370	3170	3360	3700	5200	6200
7000	2800	3150	4020	4300	4650	6600	7800
8000	3430	3940	5020	5300	5770	8400	9500
9000	4160	4800	6100	6380	6970	10100	11400
10000	4920	5730	7200	7520	8340	11800	13400
11000	5800	6800	8410	8750	9880	13600	15600
12000	6700	8000	9750	10070	11550	15400	-
13000	7620	9200	11200	11460	13260	17300	-
14000	8620	10500	12780	13100	15180	-	-
15000	9730	12150	14600	14900	17300	-	-

The iron for which data are given in columns 1 to 7 is described as follows:—

1. Very soft iron wire (taken from a former paper).

2*a*. Sheet iron 1.95 millimetres thick } almost alike.
2*b*. Thin sheet iron 0.367 millimetres thick } almost alike.

3. Iron wire 0.975 millimetres diameter.
4. Iron wire of hedgehog transformer 0.602 millimetres diameter.
5. Thin sheet iron 0.47 millimetres thick.
6. Fine iron wire 0.2475 millimetres diameter.
7. Fine iron wire 0.34 millimetres diameter.

* Ewing and Klassen, "Phil. Trans. Roy. Soc." vol. clxxxiv. A, p. 1015.

MAGNETO-OPTIC ROTATION.

Faraday discovered that, when a piece of heavy glass is placed in magnetic field and a beam of plane polarized light passed through it in a direction parallel to the lines of magnetic force, the plane of polarization of the beam is rotated. This was subsequently found to be the case with a large number of substances, but the amount of the rotation was found to depend on the kind of matter and its physical condition, and on the strength of the magnetic field and the wave-length of the polarized light. Verdet's experiments agree fairly well with the formula —

$$\theta = clH\left(r - \lambda\frac{dr}{d\lambda}\right)\frac{r^2}{\lambda^2},$$

where c is a constant depending on the substance used, l the length of the path through the substance, H the intensity of the component of the magnetic field in the direction of the path of the beam, r the index of refraction, and λ the wave-length of the light in air. If H be different, at different parts of the path, lH is to be taken as the integral of the variation of magnetic potential between the two ends of the medium. Calling this difference of potential v, we may write $\theta = Av$, where A is constant for the same substance, kept under the same physical conditions, when the one kind of light is used. The constant A has been called "Verdet's constant,"[*] and a number of values of it are given in Tables 303–310. For variation with temperature the following formula is given by Bichat: —

$$R = R_0\,(1 - 0.00104\,t - 0.0000014\,t^2),$$

which has been used to reduce some of the results given in the table to the temperature corresponding to a given measured density. For change of wave-length the following approximate formula, given by Verdet and Becquerel, may be used: —

$$\frac{\theta_1}{\theta_2} = \frac{\mu_1^2(\mu_1^2 - 1)\lambda_2^2}{\mu_2^2(\mu_2^2 - 1)\lambda_1^2},$$

where μ is index of refraction and λ wave-length of light.

A large number of measurements of what has been called molecular rotation have been made, particularly for organic substances. These numbers are not given in the table, but numbers proportional to molecular rotation may be derived from Verdet's constant by multiplying in the ratio of the molecular weight to the density. The densities and chemical formulæ are given in the table. In the case of solutions, it has been usual to assume that the total rotation is simply the algebraic sum of the rotations which would be given by the solvent and dissolved substance, or substances, separately; and hence that determinations of the rotary power of the solvent medium and of the solution enable the rotary power of the dissolved substance to be calculated. Experiments by Quincke and others do not support this view, as very different results are obtained from different degrees of saturation and from different solvent media. No results thus calculated have been given in the table, but the qualitative result, as to the sign of the rotation produced by a salt, may be inferred from the table. For example, if a solution of a salt in water gives Verdet's constant less than 0.0130 at 20° C., Verdet's constant for the salt is negative.

The table has been for the most part compiled from the experiments of Verdet,[†] H. Becquerel,[‡] Quincke,[§] Koepsel,[‖] Arons,[¶] Kundt,[**] Jahn,[††] Schönrock,[‡‡] Gordon,[§§] Rayleigh and Sidgewick,[‖‖] Perkin,[¶¶] Bichat.[***]

As a basis for calculation, Verdet's constant for carbon disulphide and the sodium line D has been taken as 0.0420 and for water as 0.0130 at 20° C.

[*] The constancy of this quantity has been verified through a wide range of variation of magnetic field by H. E. J. G. Du Bois (Wied. Ann. vol. 35).
[†] "Ann. de Chim. et de Phys." [3] vol. 52.
[‡] "Ann. de Chim. et de Phys." [5] vol. 12; "C. R." vols. 90 and 100.
[§] "Wied. Ann." vol. 24.
[‖] "Wied. Ann." vol. 26.
[¶] "Wied. Ann." vol. 24.
[**] "Wied. Ann." vols. 23 and 27.
[††] "Wied. Ann." vol. 43.
[‡‡] "Zeits. für Phys. Chem." vol. 11.
[§§] "Proc. Roy. Soc." 1883.
[‖‖] "Phil. Trans. R. S." 1885.
[¶¶] "Jour. Chem. Soc." vols. 8 and 12.
[***] "Jour. de Phys." vols. 8 and 9.

MAGNETO-OPTIC ROTATION.

Solids.

Substance.	Chemical formula.	Density or grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Amber	–	–	D	0.0095	18–20°	Quincke.
Blende	ZnS	–	"	0.2234	15	Becquerel.
Diamond	C	–	"	0.0127	"	"
Fluor spar	$CaFl_2$	–	"	0.0087	"	"
Glass:						
Crown	–	–	"	0.0203	"	"
Faraday A	–	5.458	"	0.0782	18–20	Quincke.
" B	–	4.284	"	0.0649	"	"
Flint	–	–	"	0.0420	"	"
"	–	–	"	0.0325	15	Becquerel.
"	–	–	"	0.0416	"	"
" dense	–	–	"	0.0576	"	"
" "	–	–	"	0.0647	"	"
Plate	–	–	"	0.0406	18–20	Quincke.
Lead borate	PbB_2O_4	–	"	0.0600	15	Becquerel.
Quartz (perpendicular to axis)	–	–	"	0.0172	18–20	Quincke.
Rock salt	NaCl	–	"	0.0355	15	Becquerel.
Selenium	Se	–	B	0.4625	"	"
Sodium borate	$Na_2B_4O_7$	–	D	0.0170	"	"
Spinel (colored by chrome)	–	–	"	0.0209	"	"
Sylvine	KCl	–	"	0.0283	"	"
Ziqueline (suboxide of copper)	Cu_2O	–	B	0.5908	"	"

MAGNETO-OPTIC ROTATION.

Liquids.

Substance.	Chemical formula.	Density in grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Acetone	C_3H_6O	0.7947	D	0.0113	20	Jahn.
"	"	0.7957	"	0.0115	15	Perkin.
"	"	0.7947	"	0.0114	16	Schönrock.
Acids: (see also solutions in water)						
Acetic	$C_2H_4O_2$	1.0561	"	0.0105	21	Perkin.
Butyric	$C_4H_8O_2$	0.9663	"	0.0110	15	"
Formic	CH_2O_2	1.2273	"	0.0105	15	"
Hydrochloric . . .	HCl	1.2072	"	0.0224	15	"
"	"	–	"	0.0206	15	Becquerel.
Hydrobromic . . .	HBr	1.7859	"	0.0343	15	Perkin.
Hydroiodic	HI	1.9473	"	0.0513	15	"
Nitric	HNO_3	1.5190	"	0.0070	13	"
" (fuming) . . .	"	–	"	0.0080	15	Becquerel.
Propionic	$C_3H_6O_2$	0.9975	"	0.0110	15	Perkin.
Sulphuric	H_2SO_4	–	"	0.0121	15	Becquerel.
Sulphurous	H_2SO_3	–	"	0.0153	15	"
Valeric	$C_5H_{10}O_2$	0.9438	"	0.0121	15	Perkin.
Alcohols:						
Amyl	$C_5H_{11}OH$	–	"	0.0131	15	Becquerel.
"	"	0.8107	"	0.0128	20	Jahn.
Butyl	C_4H_9OH	0.8021	"	0.0124	20	"
"	"	–	"	0.0124	15	Becquerel.
Ethyl	C_2H_5OH	0.7929	"	0.0107	18–20	Quincke.
"	"	0.7900	"	0.0112	20	Jahn.
"	"	0.7944	"	0.0114	15	Perkin.
"	"	0.7943	"	0.0113	16	Schönrock.
Methyl	CH_3OH	0.7915	"	0.0094	18–20	Quincke.
"	"	0.7920	"	0.0093	20	Jahn.
"	"	–	"	0.0100	15	Becquerel.
"	"	0.7966	"	0.0096	15	Perkin.
"	"	0.7903	"	0.0096	21.9	Schönrock.
Octyl	$C_8H_{17}OH$	0.8276	"	0.0134	15	Perkin.
Propyl	C_3H_7OH	0.8050	"	0.0120	20.8	Schönrock.
"	"	0.8082	"	0.0120	15.0	Perkin.
"	"	–	"	0.0118	15	Becquerel.
"	"	0.8042	"	0.0120	20	Jahn.
Benzene	C_6H_6	0.8786	"	0.0297	20	Jahn.
"	"	–	"	0.0268	15	Becquerel.
"	"	0.8718	"	0.0301	26.9	Schönrock.
Bromides:						
Bromoform	$CHBr_3$	2.9021	"	0.0317	15	Perkin.
Ethyl	C_2H_5Br	1.4486	"	0.0183	15	"
Ethylene	$C_2H_4Br_2$	2.1871	"	0.0268	15	"
"	"	2.1780	"	0.0269	20	Jahn.
Methyl	CH_3Br	1.7331	"	0.0205	0	Perkin.
Methylene	CH_2Br_2	2.4971	"	0.0276	15	"
Octyl	$C_8H_{17}Br$	1.1170	"	0.0164	15	"
Propyl	C_3H_7Br	1.3600	"	0.0180	15	"
Carbon disulphide . . .	CS_2	1.2644	"	0.0441	18–20	Quincke.
" "	"	–	"	0.0434	0	Becquerel, 1885.
" "	"	–	"	0.0433	0	Gordon.
" "	"	–	"	0.0420	18	Rayleigh.
" "	"	–	"	0.0420	18	Koepsel.
" "	"	–	"	0.0439	0	Arons.

MAGNETO-OPTIC ROTATION

Liquids.

Substance.	Chemical formula.	Density in grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Chlorides:						
Amyl	CHCl	0.8740	D	0.0140	20	Jahn.
Arsenic	As	–	"	0.0422	15	Becquerel.
Carbon	C	–	"	0.0170	15	"
" bichloride	CCl_4	–	"	0.0321	15	"
Chloroform	$CHCl_3$	1.4823	"	0.0164	20	Jahn.
"	"	1.4990	"	0.0166	15	Perkin.
Ethyl	C_2H_5Cl	0.9169	"	0.0138	6	"
Ethylene	$C_2H_4Cl_2$	1.2589	"	0.0166	15	"
"	"	1.2561	"	0.0164	20	Jahn.
Methyl	CH_3Cl	–	"	0.0170	15	Becquerel.
Methylene	CH_2Cl_2	1.3361	"	0.0162	15	Perkin.
Octyl	$C_8H_{17}Cl$	0.8778	"	0.0141	15	"
Phosphorus protochloride	PCl_3	–	"	0.0275	15	Becquerel.
Propyl	C_3H_7Cl	0.8922	"	0.0135	15	Perkin.
Silicon	$SiCl_4$	–	"	0.0275	15	Becquerel.
Sulphur bichloride	S_2Cl_2	–	"	0.0393	15	"
Tin bichloride	$SnCl_4$	–	"	0.0151	15	"
Zinc bichloride	$ZnCl_2$	–	"	0.0437	15	"
Iodides:						
Ethyl	C_2H_5I	1.9417	"	0.0296	15	Perkin.
Methyl	CH_3I	2.2832	"	0.0336	15	"
Octyl	$C_8H_{17}I$	1.3395	"	0.0213	15	"
Propyl	C_3H_7I	1.7658	"	0.0271	15	"
Nitrates:						
Ethyl	$C_2H_5O.NO_2$	1.1149	"	0.0091	15	"
Ethylene (nitroglycol)	$C_2H_4(NO_3)_2$	1.4948	"	0.0088	15	"
Methyl	$CH_3O.NO_2$	1.2157	"	0.0078	15	"
Propyl	$C_3H_7O.NO_2$	1.0622	"	0.0100	15	"
Trinitrin (nitroglycerine)	$C_3H_5(NO_3)_3$	1.5996	"	0.0090	15	"
Nitro ethane	$C_2H_5NO_2$	1.0552	"	0.0095	15	"
Nitro methane	CH_3NO_2	1.1432	"	0.0084	15	"
Nitro propane	$C_3H_5NO_2$	1.0100	"	0.0102	15	"
Paraffins:						
Decane	$C_{10}H_{22}$	0.7218	"	0.0128	23.1	Schönrock.
Heptane	C_7H_{16}	0.6880	"	0.0125	15	Perkin.
Hexane	C_6H_{14}	0.6580	"	0.0122	22.1	Schönrock.
"	"	0.6743	"	0.0125	15	Perkin.
Octane	C_8H_{18}	0.7011	"	0.0128	23.1	Schönrock.
Pentane	C_5H_{12}	0.6196	"	0.0119	21.1	"
"	"	0.6332	"	0.0118	15	Perkin.
Phosphorus (melted)	P	–	"	0.1316	33	Becquerel.
Sulphur (melted)	S	–	"	0.0803	114	"
Toluene	C_7H_8	0.8581	"	0.0269	28.4	Schönrock.
"	"	–	"	0.0243	15	Becquerel.
Water	H_2O	0.9992	"	0.0130	15	"
"	"	0.9983	"	0.0131	18–20	Quincke.
"	"	0.9983	"	0.0132	20	Jahn.
Xylene	C_8H_{10}	–	"	0.0221	15	Becquerel.
"	"	0.8746	"	0.0263	27	Schönrock.

MAGNETO-OPTIC ROTATION.

Solutions of Acids and Salts in Water.

Substance.	Chemical formula.	Density, grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Acetone	C_3H_6O	0.9715	D	0.0129	20°	Jahn.
Acids:						
Hydrobromic	HBr	1.7859	"	0.0343	15	Perkin.
"	"	1.6104	"	0.0304	"	"
"	"	1.3775	"	0.0244	"	"
"	"	1.2039	"	0.0194	"	"
"	"	1.1163	"	0.0168	"	"
Hydrochloric . . .	HCl	1.2072	"	0.0225	"	"
"	"	1.1856	"	0.0219	"	"
"	"	1.1573	"	0.0204	"	"
"	"	1.1279	"	0.0193	"	"
"	"	1.0762	"	0.0168	"	"
"	"	1.0323	"	0.0150	20	Jahn.
"	"	1.0158	"	0.0140	"	"
Hydriodic	HI	1.9473	"	0.0513	"	Perkin.
"	"	1.9057	"	0.0499	"	"
"	"	1.8229	"	0.0468	"	"
"	"	1.7007	"	0.0421	"	"
"	"	1.4495	"	0.0323	"	"
"	"	1.2966	"	0.0258	"	"
"	"	1.1760	"	0.0205	"	"
Nitric	HNO_3	1.5190	"	0.0010	"	"
"	"	1.3560	"	0.0105	"	"
Sulphuric + $3H_2O$ . .	H_2SO_4	–	"	0.0121	"	Becquerel.
Ammonia	NH_3	0.8918	"	0.0153	15	Perkin.
Bromides:						
Ammonium	NH_4Br	1.2805	"	0.0226	"	"
"	"	1.1576	"	0.0186	"	"
Barium	$BaBr_2$	1.5399	"	0.0215	20	Jahn.
"	"	1.2855	"	0.0176	"	"
Cadmium	$CdBr_2$	1.3291	"	0.0192	"	"
"	"	1.1608	"	0.0162	"	"
Calcium	$CaBr_2$	1.2491	"	0.0189	"	"
"	"	1.1337	"	0.0164	"	"
Potassium	KBr	1.1424	"	0.0163	"	"
"	"	1.0876	"	0.0151	"	"
Sodium	NaBr	1.1351	"	0.0165	"	"
"	"	1.0824	"	0.0152	"	"
Strontium	$SrBr_2$	1.2901	"	0.0186	"	"
"	"	1.1416	"	0.0159	"	"
Carbonate of potassium . .	K_2CO_3	1.1906	"	0.0140	20	"
" " sodium . .	Na_2CO_3	1.1006	"	0.0140	"	"
" " " . .	"	1.0564	"	0.0137	"	"
Chlorides:						
Ammonium (sal ammoniac)	NH_4Cl	1.0718	"	0.0178	15	Verdet.
Barium	$BaCl_2$	1.2897	"	0.0168	20	Jahn.
"	"	1.1338	"	0.0149	"	"
Cadmium	$CdCl_2$	1.3179	"	0.0185	"	"
"	"	1.2755	"	0.0179	"	"
"	"	1.1732	"	0.0160	"	"
"	"	1.1531	"	0.0157	"	"
Calcium	$CaCl_2$	1.1504	"	0.0165	"	"
"	"	1.0832	"	0.0152	"	"
"	"	1.1049	"	0.0157	16	Schönrock.
Copper	$CuCl_2$	1.5158	"	0.0221	15	Becquerel.
"	"	1.2789	"	0.0186	"	"
"	"	1.1330	"	0.0156	"	"

MAGNETO-OPTIC ROTATION.

Solutions of Acids and Salts in Water.

Substance.	Chemical formula.	Density, grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Chlorides:						
Iron	$FeCl_2$	1.4331	D	0.0025	15°	Becquerel.
"	"	1.2141	"	0.0099	"	"
"	"	1.1093	"	0.0118	"	"
"	"	1.0548	"	0.0124	"	"
" (ferric) . .	Fe_2Cl_6	1.6933	"	—0.2026	"	"
"	"	1.5315	"	—0.1140	"	"
"	"	1.3230	"	—0.0348	"	"
"	"	1.1681	"	—0.0015	"	"
"	"	1.0864	"	0.0081	"	"
"	"	1.0445	"	0.0113	"	"
"	"	1.0232	"	0.0122	"	"
Lithium	LiCl	1.0619	"	0.0145	20	Jahn.
"	"	1.0316	"	0.0143	"	"
Manganese . . .	$MnCl_2$	1.1966	"	0.0167	15	Becquerel.
"	"	1.0876	"	0.0150	"	"
Mercury . . .	$HgCl_2$	1.0381	"	0.0137	16	Schönrock.
"	"	1.0349	"	0.0137	"	"
Nickel	$NiCl_2$	1.4685	"	0.0270	15	Becquerel.
"	"	1.2432	"	0.0196	"	"
"	"	1.1233	"	0.0162	"	"
"	"	1.0690	"	0.0146	"	"
Potassium . . .	KCl	1.6000	"	0.0163	"	"
"	"	1.0732	"	0.0148	20	Jahn.
"	"	1.0418	"	0.0144	"	"
Sodium . . .	NaCl	1.2051	"	0.0180	15	Becquerel.
"	"	1.1058	"	0.0155	"	"
"	"	1.0546	"	0.0144	"	"
"	"	1.0817	"	0.0154	20	Jahn.
"	"	1.0418	"	0.0144	"	"
Strontium . . .	$SrCl_2$	1.1921	"	0.0162	"	"
"	"	1.0877	"	0.0146	"	"
Tin	$SnCl_2$	1.3280	"	0.0266	15	Verdet.
"	"	1.1637	"	0.0198	"	"
"	"	1.1112	"	0.0175	"	"
Zinc	$ZnCl_2$	1.2851	"	0.0196	"	"
"	"	1.1595	"	0.0161	"	"
Chromate of potassium .	K_2CrO_4	1.3598	"	0.0098	"	"
Bichromate of " .	$K_2Cr_2O_7$	1.0786	"	0.0126	"	"
Cyanide of mercury .	$Hy(CN)_2$	1.0638	"	0.0136	16	Schönrock.
" " " .	"	1.0425	"	0.0134	"	"
" " " .	"	1.0605	"	0.0135	"	"
Iodides:						
Ammonium . . .	NH_4I	1.5948	"	0.0396	15	Perkin.
"	"	1.5688	"	0.0386	"	"
"	"	1.5109	"	0.0358	"	"
"	"	1.2341	"	0.0235	"	"
Cadmium . . .	CdI	1.5156	"	0.0291	20	Jahn.
"	"	1.2770	"	0.0215	"	"
"	"	1.1521	"	0.0177	"	"
Potassium . . .	KI	1.6743	"	0.0338	15	Becquerel.
"	"	1.3398	"	0.0237	"	"
"	"	1.1705	"	0.0182	"	"
"	"	1.0871	"	0.0152	"	"
"	"	1.2380	"	0.0211	20	Jahn.
"	"	1.1245	"	0.0174	"	"
Sodium . . .	NaI	1.1939	"	0.0200	"	"
"	"	1.1191	"	0.0175	"	"

MAGNETO-OPTIC ROTATION.

TABLE 305. — Solutions of Acids and Salts in Water.

Substance.	Chemical formula.	Density, grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Nitrates:						
Ammonium	NH_4NO_3	1.2803	D	0.0121	15	Perkin.
Potassium	KNO_3	1.0634	"	0.0130	20	Jahn.
Sodium	$NaNO_3$	1.1112	"	0.0131	"	"
Uranium	$U_2O_3.N_2O_5$	2.0267	"	0.0053	"	Becquerel.
"	"	1.7640	"	0.0078	"	"
"	"	1.3865	"	0.0105	"	"
"	"	1.1963	"	0.0115	"	"
Sulphates:						
Ammonium	$(NH_4)_2SO_4$	1.2286	"	0.0140	15	Perkin.
" (acid)	$NH_4.HSO_4$	1.4417	"	0.0085	"	"
Barium	$BaSO_4$	1.1788	"	0.0134	20	Jahn.
"	"	1.0938	"	0.0133	"	"
Cadmium	$CdSO_4$	1.1762	"	0.0139	"	"
"	"	1.0890	"	0.0136	"	"
Lithium	Li_2SO_4	1.1762	"	0.0137	"	"
"	"	1.0942	"	0.0135	"	"
Manganese	$MnSO_4$	1.2441	"	0.0138	"	"
"	"	1.1416	"	0.0136	"	"
Potassium	K_2SO_4	1.0475	"	0.0133	"	"
Sodium	$NaSO_4$	1.0661	"	0.0135	"	"

TABLE 306. — Solutions of Salts in Alcohol.

Substance.	Chemical formula.	Density, grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Cadmium bromide	$CdBr_2$	1.0446	D	0.0159	20	Jahn.
" "	"	0.9420	"	0.0140	"	"
Calcium "	$CaBr_2$	0.9966	"	0.0154	"	"
" "	"	0.8846	"	0.0130	"	"
Strontium "	$SrBr_2$	0.9636	"	0.0140	"	"
" "	"	0.8814	"	0.0126	"	"
Cadmium chloride	$CdCl_2$	0.8303	"	0.0118	"	"
Strontium "	$SrCl_2$	0.8313	"	0.0118	"	"
" "	"	0.8274	"	0.0117	"	"
Cadmium iodide	CdI_2	1.0988	"	0.0199	"	"
" "	"	0.9484	"	0.0156	"	"

TABLE 307. — Solutions in Hydrochloric Acid.

Substance.	Chemical formula.	Density, grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Antimony trichloride	$SbCl_3$	2.4755	D	0.0603	15	Becquerel.
" "	"	1.8573	"	0.0449	"	"
" "	"	1.5195	"	0.0347	"	"
" "	"	1.3420	"	0.0277	"	"
Bismuth "	$BiCl_3$	2.0822	"	0.0396	"	"
" "	"	1.6550	"	0.0359	"	"
" "	"	1.4156	"	0.0350	"	"

MAGNETO-OPTIC ROTATION.

Gases.

Substance.	Pressure.	Temp.	Verdet's constant in minutes.	Authority.
Atmospheric air	Atmospheric	Ordinary	6.83×10^{-6}	Becquerel.
Carbon dioxide	"	"	13.00 "	"
Carbon disulphide	74 cms.	70° C.	23.49 "	Bichat.
Ethylene	Atmospheric	Ordinary	34.48 "	Becquerel.
Nitrogen	"	"	6.92 "	"
Nitrous oxide	"	"	16.90 "	"
Oxygen	"	"	6.28 "	"
Sulphur dioxide	"	"	31.39 "	"
" "	246 cms.	20° C.	38.40 "	Bichat.

Du Bois discusses Kundt's results and gives additional experiments on nickel and cobalt. He shows that in the case of substances like iron, nickel, and cobalt which have a variable magnetic susceptibility the expression in Verdet's equation, which is constant for substances of constant susceptibility, requires to be divided by the susceptibility to obtain a constant. For this expression he proposes the name "Kundt's constant." These experiments of Kundt and Du Bois show that it is not the difference of magnetic potential between the two ends of the medium, but the product of the length of the medium and the induction per unit area, which controls the amount of rotation of the beam.

VERDET'S AND KUNDT'S CONSTANTS.

The following short table is quoted from Du Bois' paper. The quantities are stated in c. g. s. measure, circular measure (radians) being used in the expression of "Verdet's constant" and "Kundt's constant."

Name of substance.	Magnetic susceptibility.	Verdet's constant.		Wave-length of light in cms.	Kundt's constant.
		Number.	Authority.		
Cobalt	-	-	-	6.44×10^{-5}	3.99
Nickel	-	-	-	"	3.15
Iron	-	-	-	6.56 "	2.63
Oxygen: 1 atmo. .	$+0.0126 \times 10^{-6}$	0.000179×10^{-6}	Becquerel.	5.89 "	0.014
Sulphur dioxide .	−0.0751 "	0.302 "	"	"	−4.00
Water . . .	−0.0694 "	0.377 "	Arons	"	−5.4
Nitric acid . .	−0.0633 "	0.356 "	Becquerel.	"	−5.6
Alcohol . . .	−0.0566 "	0.330 "	De la Rive.	"	−5.8
Ether	−0.0541 "	0.315 "	"	"	−5.8
Arsenic chloride .	−0.0876 "	1.222 "	Becquerel.	"	−14.9
Carbon disulphide .	−0.0716 "	1.222 "	Rayleigh.	"	−17.1
Faraday's glass .	−0.0982 "	1.738 "	Becquerel.	"	−17.7

TABLE 310.

MAGNETIC SUSCEPTIBILITY OF LIQUIDS AND GASES.

The following table gives a comparison by Du Bois * of his own and some other determinations of the magnetic susceptibility of a few standard substances. Verdet's and Kundt's constants are in radians for the sodium line D.

Substance.	Verdet's constant.	Faraday's value $k \times 10^6$	Becquerel's value $k \times 10^6$	Wähner's value $k \times 10^6$
Water	3.77×10^{-6}	—0.69	—0.63	—0.536
Alcohol, C_2H_6O . . .	3.30 "	—0.57	—0.49	—0.388
Ether, $C_4H_{10}O$ . . .	3.15 "	—0.54	-	—0.360
Carbon disulphide . .	12.22 "	—0.72	—0.84	—0.465
Oxygen at 1 atmosphere .	0.00179 "	0.13	0.12	-
Air at 1 atmosphere . .	0.00194 "	0.024	0.025	-

Substance.	Quincke at 20° C.		Du Bois at 15° C.		
	Density.	$k \times 10^6$	Density.	$k \times 10^6$	Kundt's constant.
Water	0.9983	—0.815	0.9992	—0.837	—4.50
Alcohol, C_2H_6O . . .	0.7929	—0.660	0.7963	—0.694	—4.75
Ether, $C_4H_{10}O$ . . .	0.7152	—0.607	0.7250	—0.642	—4.91
Carbon disulphide . .	1.2644	—0.724	1.2692	—0.816	—14.97
Oxygen at 1 atmosphere .	-	-	0.00135	0.117	0.016
Air at 1 atmosphere . .	-	-	0.00123	0.024	0.081

TABLE 311.

VALUES OF KERR'S CONSTANT.†

Du Bois has shown that the rotation of the major axis of vibration of radiations normally reflected from a magnet is algebraically equal to the normal component of magnetization multiplied into a constant K. He calls this constant, K, Kerr's constant for the magnetized substance forming the magnet.

Color of light.	Spectrum line.	Wave-length in cms. $\times 10^6$	Kerr's constant in minutes per c. g. s. unit of magnetization.			
			Cobalt.	Nickel.	Iron.	Magnetite.
Red	Li α	67.7	—0.0208	—0.0173	—0.0154	+0.0096
Red	—	62.0	—0.0198	—0.0160	—0.0138	+0.0120
Yellow . . .	D	58.9	—0.0193	—0.0154	—0.0130	+0.0133
Green . . .	*b*	51.7	—0.0179	—0.0159	—0.0111	+0.0072
Blue	F	48.6	—0.0180	—0.0163	—0.0101	+0.0026
Violet . . .	G	43.1	—0.0182	—0.0175	—0.0089	-

* "Wied. Ann." vol. 35, p. 163.

† H. E. J. G. Du Bois, "Phil. Mag." vol. 29.

EFFECT OF MAGNETIC FIELD ON THE ELECTRIC RESISTANCE OF BISMUTH.*

TABLE 312. — Resistance One Ohm for Zero Field and Various Temperatures.

This table gives the resistance to the flow of a steady electric current when conveyed across a magnetic field of the strength in c. g. s. units given in the first column if the wire has a resistance of one ohm at the temperature given at the top of the column when the field is of zero strength.

Temp. C.=	0°	10°	18°	30°	50°	80°
Field.	Resistance.					
000	1.000	1.000	1.000	1.000	1.000	1.000
1000	1.018	1.019	1.018	1.017	1.014	1.007
2000	1.045	1.050	1.045	1.041	1.034	1.015
3000	1.088	1.094	1.084	1.074	1.055	1.032
4000	1.135	1.153	1.131	1.118	1.085	1.050
5000	1.185	1.214	1.183	1.156	1.113	1.074
6000	1.240	1.273	1.242	1.202	1.148	1.100
7000	1.304	1.340	1.295	1.258	1.190	1.127
8000	1.365	1.406	1.358	1.308	1.223	1.154
9000	1.423	1.467	1.417	1.355	1.266	1.182
10000	1.480	1.535	1.480	1.409	1.303	1.203
15000	1.743	1.875	1.785	1.665	1.505	1.343
20000	–	2.507	2.087	1.927	1.713	1.490
25000	–	2.846	2.393	2.193	1.931	1.804
30000	–	–	2.704	–	–	–
35000	–	–	3.031	–	–	–
40000	–	–	3.369	–	–	–

TABLE 313. — Resistance One Ohm for Zero Field and Temperature Zero Centigrade.

This table gives the resistance in different magnetic fields and at different temperatures of a wire, the resistance of which is one ohm at 0° C., when the magnetic field is zero. The current is supposed to be steady and to flow across the field.

Temp. C.=	0°	10°	18°	30°	50°	80°
Field.	Resistance.					
0000	1.000	1.037	1.072	1.115	1.200	1.332
1000	1.018	1.057	1.091	1.129	1.217	1.341
2000	1.045	1.089	1.118	1.156	1.241	1.352
3000	1.088	1.134	1.162	1.198	1.266	1.375
4000	1.135	1.198	1.210	1.246	1.302	1.397
5000	1.185	1.260	1.265	1.290	1.335	1.428
6000	1.240	1.323	1.327	1.341	1.379	1.464
7000	1.304	1.392	1.385	1.404	1.428	1.500
8000	1.365	1.458	1.453	1.460	1.465	1.536
9000	1.423	1.523	1.515	1.509	1.520	1.573
10000	1.480	1.592	1.583	1.573	1.562	1.610
15000	1.743	1.946	1.907	1.860	1.805	1.784
20000	–	2.295	2.243	2.148	2.055	1.980
25000	–	2.645	2.560	2.445	2.320	2.157

* Calculated from the results of J. B. Henderson's experiments, "Phil. Mag." vol. 38, p. 488.

SPECIFIC HEATS OF VARIOUS SOLIDS AND LIQUIDS.*

SOLIDS.

Substance.	Temperature in degrees C.	Specific heat.	Authority.
Alloys:			
Bell metal	15–98	0.0858	R
Brass, red	0	.08991	L
" yellow	0	.08831	"
80 Cu + 20 Sn	14–98	.0862	R
88.7 Cu + 11.3 Al	20–100	.10432	Ln
German silver	0–100	.09464	T
Lipowitz alloy: 24.97 Pb + 10.13 Cd + 50.66 Bi + 14.24 Sn	5–50	.0345	M
ditto	100–150	.0426	"
Rose's alloy: 27.5 Pb + 48.9 Bi + 23.6 Sn	—77–20	.0356	S
ditto	20–89	.0552	"
Wood's alloy: 25.85 Pb + 6.99 Cd + 52.43 Bi + 14.73 Sn	5–50	.0352	M
ditto (fluid)	100–150	.0426	"
Miscellaneous alloys:			
17.5 Sb + 29.9 Bi + 18.7 Zn + 33.9 Sn	20–99	.05657	R
37.1 Sb + 62.9 Pb	10–98	.03880	"
39.9 Pb + 60.1 Bi	16–99	.03165	P
ditto (fluid)	144–358	.03500	"
63.7 Pb + 36.3 Sn	12–99	.04073	R
46.7 Pb + 53.3 Sn	10–99	.04507	"
63.8 Bi + 36.2 Sn	20–99	.04001	"
46.9 Bi + 53.1 Sn	20–99	.04504	"
$CdSn_2$	—77–20	.05537	"
Basalt	20–100	.20–.24	–
Calcspar	16–48	.206	K
Diamond	—50.5	.0635	H W
"	10.7	.1128	"
"	140.0	.2218	"
"	206.0	.2733	"
"	606.7	.4408	"
"	985	.4589	"
Gas coal	20–1040	.3145	–
Glass, crown	10–50	.161	H M
" flint	10–50	.117	"
" mirror	10–50	.186	"
Gneiss	—19–20	.1726	R W
"	17–213	.2143	"
Granite	0–100	.19–.20	J & B
Graphite	—50.3	.1138	H W
"	10.8	.1604	"
"	138.5	.2542	"
"	201.6	.2966	"
"	641.9	.4450	"
"	977.0	.4670	"
"	16–1040	.310	D

REFERENCES.

A M = A. M. Mayer. B = Batelli. D = Dewar. E = Emo.
G & T = Gee & Terry. H & D = De Heen & Deruyts. H M = H. Meyer.
H W = H. F. Weber. J & B = Joly & Bartoli. K = Kopp.
L = Lorenz. Ln = Luginin. M = Mazotto. Ma = Marignac.
P = Person. Pa = Pagliani. Pn = Pionchon. R = Regnault.
R W = R. Weber. T = H. Tomlinson. Th = Thomsen. W = Wachsmuth.

* Condensed from more extensive tables given in Landolt and Börnstein's "Phys. Chem. Tab."

SPECIFIC HEATS OF VARIOUS SOLIDS AND LIQUIDS.

Substance.	Temperature in degrees C.	Specific heat.	Authority.
Gypsum	16–46	0.259	K
Ice	—78–0	.4627	R
"	—30–0	.505	P
"	—21–1	.5017	"
India rubber (Para)	?–100	.481	G & T
Marble, white	16–98	.2158	R
" gray	23–98	.2099	"
Paraffin	—20–3	.3768	R W
"	—19–20	.5251	"
"	0–20	.6939	"
"	35–40	.622	B
" fluid	60–63	.712	"
Quartz	0	.1735	Pn
"	350	.2786	"
"	400–1200	.305	"
Sulphur, cryst.	17–45	.163	K
Vulcanite	20–100	.3312	A M
LIQUIDS.			
Alcohol, ethyl	—20	0.5053	R
" "	0	.5475	"
" "	40	.6479	"
" methyl	5–10	.5901	"
" "	15–10	.6009	"
Benzene	10	.3402	H & D
"	40	.4233	"
Ethyl ether	0	.5290	R
Glycerine	15–50	.576	E
Oils, castor	–	.434	W
" citron	5.4	.438	H W
" olive	6.6	.471	"
" sesame	–	.387	W
" turpentine	0	.4106	R
Petroleum	21–58	.511	Pa
$CuSO_4 + 50 H_2O$	12–15	.848	"
" $+ 200 H_2O$	12–14	.951	"
" $+ 400 H_2O$	13–17	.975	"
$ZnSO_4 + 50 H_2O$	20–52	.842	Ma
" $+ 200 H_2O$	20–52	.952	"
$KOH + 30 H_2O$	18	.876	Th
" $+ 200 H_2O$	18	.975	"
$NaOH + 50 H_2O$	18	.942	"
" $+ 100 H_2O$	18	.983	"
$NaCl + 10 H_2O$	18	.791	"
" $+ 200 H_2O$	18	.978	"
Sea water: density 1.0043	17.5	.980	"
" " " 1.0235 (about normal)	17.5	.938	"
" " " 1.0463	17.5	.903	"

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SPECIFIC HEAT OF METALS.*

Metal.	Temperature in degrees C.	Specific heat.	Authority.	Metal.	Temperature in degrees C.	Specific heat.	Authority.
Aluminium	20	0.2135	N	Manganese	14–97	0.1217	R
"	100	.2211	"	Mercury: solid	—78 to —40	.03192	"
"	200	.2306	"	"	20–50	.03312	W
"	300	.2401	"	"	0	.03337	N
Antimony	15	.04890	"	"	100	.03284	"
"	100	.05031	"	"	200	.03235	"
"	200	.05198	"	"	250	.03212	"
"	300	.05366	"	Nickel	14–97	.10916	R
Bismuth	0	.03013	L	"	100	.11283	Pn
"	20–84	.0305	K	"	300	.14029	"
" fluid	280–380	.0363	P	"	500	.12988	"
Cadmium	21	.0551	N	"	800	.1484	"
"	100	.0570	"	"	1000	.16075	"
"	200	.0594	"	Palladium	0–100	.0592	V
"	300	.0617	"	"	0–1265	.0714	"
Calcium	0–100	.1804	B	Platinum	—78–20	.03037	S
Chromium (?)	22–51	.09975	K	"	0–100	.0323	V
Cobalt	9–97	.10674	R	"	0–784	.0365	"
"	500	.14516	Pn	"	0–1000	.0377	"
"	1000	.204	"	"	0–1177	.0388	"
Copper	0	.08988	L	"	1300	.03854	Pt
"	50	.09166	"	"	1400	.03896	"
"	17	.09244	N	"	1600	.03980	"
"	100	.09422	"	Potassium	—78.5–23	.1662	S
"	200	.09634	"	Silver	0–100	.0559	B
"	300	.09846	"	"	23	.05498	N
Gold	0–100	.0316	V	"	100	.05663	"
Iridium	0–100	.0323	"	"	200	.05877	"
"	0–1400	.0401	"	"	300	.06091	"
Iron	15	.1091	N	"	800	.076	Pn
"	100	.1151	"	" fluid	907–1100	.0748	"
"	200	.1249	"	Sodium	—79.5–17	.2830	S
"	300	.1376	"	"	—28–6	.2934	R
"	500	.17645	Pn	Tin	—78–20	.05416	S
"	700	.32431	"	"	0	.05368	L
"	720–1000	.218	"	"	50	.05534	"
"	1000–1200	.19887	"	"	75	.05643	"
Lead	—78–11	.03065	R	" fluid	250–350	.0637	P
"	15	.02993	N	" "	250	.05799	Pn
"	100	.03108	"	" "	1100	.0758	"
"	200	.03244	"	Zinc	0–100	.0935	B
" fluid	310	.03556	Sp	"	18	.0915	N
" "	360	.04096	"	"	190	.0951	"
Lithium	27–99	.9408	R	"	200	.0996	"
Magnesium	0	.2456	L	"	300	.1040	–
"	75	.2509	"	"	300–400	.122	LV

REFERENCES.

B = Bunsen. K = Kopp. L = Lorenz. LV = Le Verrier. N = Naccari.
P = Person. Pn = Pionchon. Pt = Pouillet. R = Regnault.
S = Schüz. Sp = Spring. V = Violle. W = Winkelmann.

* Condensed from Landolt and Börnstein's "Phys. Chem. Tab."

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